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VOLUME I
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Office of Noise Abatement and Control

Under Contract No. 68-01-1537

This report has been approved for general availability. The contents of this report reflect the views of the contractor, who is responsibile for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policy of EPA. This report does not constitute a standard, specification, or regulation.

FOREWORD

The Environmental Protection Agency is publishing a series of reports prepared by contractors describing the technology, cost, and economic impact of controlling the noise emissions from commercial products. It is hoped that these reports will provide information that will be useful to organizations or groups interested in developing or implementing noise regulations. This report was prepared by Wyle Laboratories under EPA Contract #68-01-1537.

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1. INTRODUCTION

Because of the notoriety of the motorcycle noise problem, several states and municipalities have enacted noise regulations specifically limiting the noise levels of both new machines and those already in use (see Appendix C). These regulations, within the last 5 years, have caused a significant decrease in the noise levels of new vehicles, and a great deal of noise reduction activity among the manufacturers. Still, the products of one manufacturer were denied registration by the State of California for several months during 1972 until adequate demonstration of noise control abilities was made.

In support of this activity, this study was commissioned to (1) determine the noise levels of current (1973) model motorcycles, (2) evaluate available motorcycle noise reduction technology to determine noise reductions feasible for future new machines, and finally (3) to estimate the increases in manufacturing cost required to achieve these noise reductions. The results are displayed in Chapter 6 on several charts and tables. Defined noise levels achievable for various motorcycle types (developed in Chapter 5) are shown along with required manufacturing cost increases. Noise levels, reductions, and estimated costs associated with specific noise sources on the machines are also given, along with limited general information on expected performance changes.

These investigations have been carried out through the use of data supplied principally by the motorcycle manufacturers listed in Appendix A, without whose cooperation a project of this sort could not have been completed. Wyle Research sincerely wishes to thank all of the listed organizations for their participation in this program.

2. STUDY APPROACH

The prime purpose of this study was to estimate the manufacturing cost increases necessitated by the reduction of noise from future motorcycle models. As a result of the noise control work which has been necessary since 1969 due to nonfederal noise regulations, the motorcycle industry has collected a substantial amount of data concerning both general motorcycle noise characteristics, and the noise produced by specific model lines. Therefore, the main body of data used in this study was available from the manufacturers. Supplemental information was obtained from exhaust system and accessory manufacturers, industry organizations, independent motorcycling journals, and independent organizations which have performed motorcycle noise measurements. Upon evaluation of all the available data, an independent physical testing program was deemed unnecessary for this study.

Initial contacts were established with firms which manufactured 95 percent of the new machines sold in the United States during 1972. These contacts resulted in personal questioning of manufacturers supplying 80 percent of the new machines sold during the first quarter of 1973. The following information was requested, as a minimum, from each contact:

1. 1971, 1972, and 1973 model brochures and prices.
2. Noise levels of all 1971, 1972, and 1973 models measured according to standard procedures – either SAE J331 or "The California Highway Patrol" (CHP) method.
3. The listed information regarding the following "subsources" of noise on a motorcycle:

   Subsources:

   - Exhaust – Outlet, Wall Radiation
   - Intake
   - Engine – Mechanical, Combustion

- Drive System – Drive Chain, Internal (primary drive, clutch, gearset)
- Tires
- Miscellaneous vibration of external parts
- Wind

Requested Information for Each Subsource:

a. Subsource noise level contribution to overall noise at 50 feet when measured per SAE J331 or CHP method

b. Typical frequency spectra with specified conditions

c. Near-field or other supplementary or clarifying data

d. Modifications accomplished in the past to achieve present levels:

  - Reduction in 50 foot overall noise level per modification
  - Change in manufacturing cost per modification

e. Modifications available for the future:

  - Reduction in overall 50 foot noise level
  - Reduction in the particular subsource noise level at 50 feet
  - Change in manufacturing cost resulting
  - Performance or styling changes required
  - Date of availability or stage of development

4. The company noise reduction timetable for implementing the above modifications.

5. The modifications intended for use to comply with future California noise level requirements, and the expected manufacturing cost changes.

6. Measurements of minimum noise achievable by unpowered passby.

7. Share of the United States motorcycle market.

8. Opinions on reasonable progressively lower future regulations and test procedures.

9. Official policy statements.

10. General corporate financial brochure.

Partial or complete responses to the inquiries were received from manufacturers which provided 93 percent of the new motorcycles sold in the United States during the first quarter of 1973. Data resulting from previous Wyle Research contacts with the motorcycle industry combined to yield a data base representing over 97 percent of new machine sales in the United States. Similar information was also received from over 50 percent of after-market exhaust system manufacturers. Many of the manufacturers considered their data proprietary, and for this reason, company names will not be identified with specific noise or cost data. The information received was sufficient to allow reasonable estimates, through the analysis described in Chapters 5 and 6, of the manufacturing cost increases associated with varying degrees of noise reduction for future new motorcycles.

3. THE MOTORCYCLE INDUSTRY

Motorcycles are an unusual consumer product on the United States market. Over 90 percent of sales consist of products of foreign origin – with 88 percent produced in Japan. The only sizable U.S. manufacturer, AMF/Harley-Davidson, represents about 5 percent of U.S. unit sales. The market also exhibits a high degree of concentration, with only six of over 40 U.S. involved manufacturers obtaining approximately 95 percent of American sales. These large manufacturers span the product range by offering the consumer machines of varied size and purpose. Also, these major suppliers manufacture a wide field of other products, or are subsidiaries of diversified manufacturers. A listing of principal suppliers of motorcycles to the United States is given in Table 1.

In addition to the principal manufacturers noted above, there are approximately 15 minor American manufacturers producing limited numbers of medium to small size machines for domestic sale. In general, foreign engine, engine silencing, and gearbox units are fitted to frames manufactured by the American factories. This sector of the market provides approximately 1 percent of United States sales, and over half of these machines are of the "minibike" variety (described in Chapter 4) which is not intended for regular licensed use. Due to the extremely low portion of machines supplied, and the very limited noise control experience of these small shops, they are not included in the project's analysis.

To preserve the confidentiality requested by industry, and in view of the homogeneous, concentrated foreign nature of nearly the entire industry supply, this study has not grouped manufacturers according to geographical, technical, or economic parameters. Rather, the following analysis will attempt to relate the costs of noise reduction to physical motorcycle characteristics.

Table 1

Market Shares of Principal Motorcycle Manufacturers Involved in the United States Market

Manufacturer	Location	Percent of Units Sold in United States[2]
Honda Motor Company	Japan	48.6
Yamaha Motor Company, Ltd.	Japan	18.9
Suzuki Motor Corporation	Japan	12.2
Kawasaki Motors Corporation	Japan	8.2
AMF/Harley-Davidson Motor Company, Inc.	U.S.A.	4.6
The Birmingham Small Arms Co., Ltd. (BSA, Triumph)[1]	England	3.2
Bavarian Motor Works	Germany	0.6
Bultaco Motors	Spain	0.6
Hodaka Industrial Co., Ltd.	Japan	0.4
OSSA	Spain	0.4
Husqvarna	Czechoslovakia	0.3
Benelli	Italy	0.2
		98.2 %

Source: 1973 CYCLE Magazine Buyers Study[2] conducted by AHF Marketing Research, Inc.

[1] The BSA Co., Ltd. has recently consolidated with other British motorcycle firms to form Norton Villiers-Triumph Corporation.

[2] Figures from other independent market studies agree closely with those of this table.

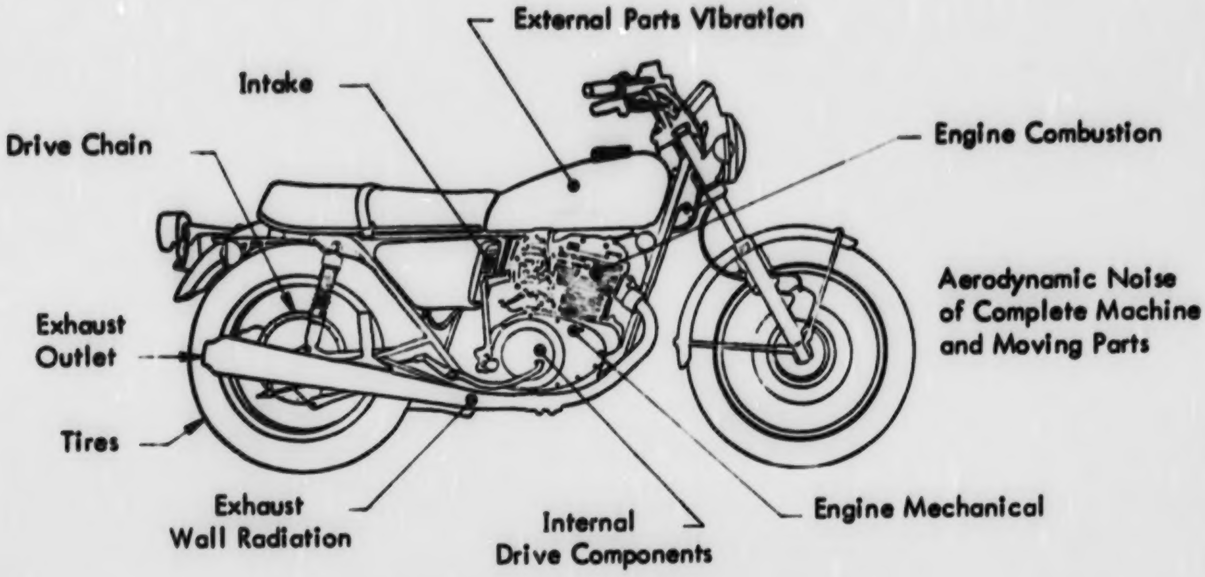
4. MOTORCYCLE CONSTRUCTION AND NOISE CHARACTERISTICS

Introduction

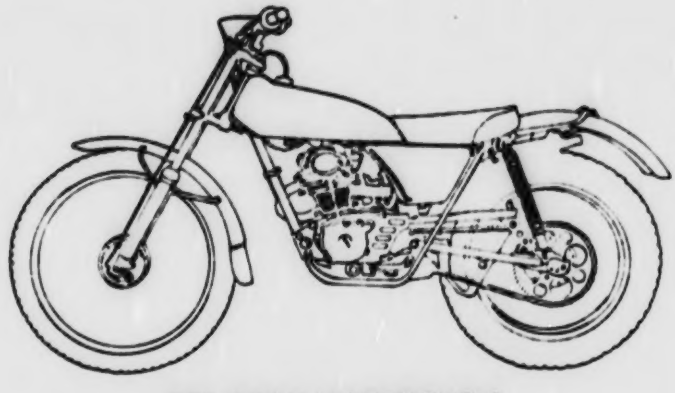
The contemporary motorcycle is a highly developed, modern, high performance transportation vehicle, and as such, becomes a notably complex source of noise. The exposed condition of the vehicle components allows several of them to contribute significantly to total vehicle noise. Basic motorcycle configurations with noise sources identified are shown in Figure 1.

With few exceptions, the motorcycle is a two wheeled vehicle powered by a carbureted spark ignition air cooled reciprocating two or four stroke cycle engine driving through a manual clutch and multiratio gearset. Motorcycle size is conventionally indicated by total engine displacement, expressed in cubic centimeters (cc). Single row roller chain conveys engine driving effort to the rear wheel. Both wheels are of the wire spoked variety, mounted on a damped spring suspension, and contain independently operated drum or disc brakes. The operation of controls for brakes, clutch, throttle, and gearset is by small hand or foot movements, and all controls can be operated simultaneously without removing hand or foot from its particular control/s. Ranges of dimensions and characteristics represented by available 1973 models are shown in Table 2. Directional changes are made through a combination of turning the handlebars – front wheel assembly, and shifting of body weight. The constant immediate availability of control mechanisms and use of subtle changes of body position creates a sensation of motoring involvement for the motorcyclist which is generally quite pleasing and sporting. This sporting interpretation is also intimately related to the machine's sound. A motorcycle's exhaust noise is often referred to by the enthusiast as a "note," indicating a kind of aural aesthetic quality. Thus, a saleable motorcycle, in addition to possessing traditional unfettered agility and stirring performance, must present an acceptably impressive sound.

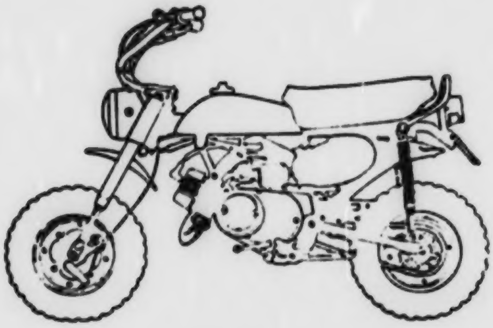
For purposes of this study, four basic styles represented by current models will be defined. Highway motorcycles, which span the entire size and performance range,


External Parts Vibration
Intake
Drive Chain
Engine Combustion
Aerodynamic Noise of Complete Machine and Moving Parts
Exhaust Outlet
Tires
Exhaust Wall Radiation
Internal Drive Components
Engine Mechanical

HIGHWAY MOTORCYCLE



OFF-ROAD MOTORCYCLE



MINIBIKE

Figure 1. Motorcycle Noise Sources and Configurations

Table 2

Manufacturer Specification Ranges for Standard Highway Motorcycles and Motor-Driven Cycles

Displacement, cc	50 to 1200
Maximum Power, hp	4.9 to 82
Maximum Engine Speed, rpm	5900 to 10,000
Specific Power Output, hp/100 cc	4.5 to 12.7
Weight, lb	143 to 722
"Power to Weight Ratio," lb/hp	5.9 to 25.5
Wheelbase, in	43.3 to 61.5
Number of Gear Ratios	3 to 10
Top Speed, mph	50 to 130
Fuel Consumption, mpg	~ 20 to 90

are standard transportation models produced for licensing and use on public highways. They contain all required safety equipment (lights, horn, passenger seat and handhold, turn signals, etc.,) and have the least critical weight and size requirements. Dual purpose motorcycles are a design compromise including features which allow reasonable operation both on the highway and in nonpaved or natural areas. Differences from pure highway machines include generally smaller components for less weight, increased ground clearance usually requiring a high mounted and smaller exhaust, changes in frame geometry, suspension, engine output characteristics, and occasionally different tire size and tread type. Off road motorcycles are designed for use over natural terrain only, and contain no features oriented toward highway use. Performance demands for off road use, which often includes racing and other competitive events, require extreme light weight, balance and agility. Thus, items such as seat, fuel tank, fenders, intake, and exhaust systems are of minimal functional dimensions. Unfortunately, this configuration has in the past produced noise levels of other than minimal dimensions.

Dual purpose and off road motorcycles are available in sizes of 500 cc or less. Minibikes exist in many forms, from accurately scaled down motorcycles to simple tube frames on small tires powered by lawn mower type engines. Intended for general off road use by children, some highly developed examples produced by large manufacturers contain the equipment necessary for highway licensing.

Sales of all four types are nearly equally divided between machines powered by two stroke cycle and four stroke cycle engines, with the exception of off road motorcycles, for which the lighter weight two-cycle engine is more common.

Average vehicle lifetime varies appreciably with machine type and use. In general, off road motorcycles are active between 3.5 and 5 years; dual purpose or highway machines under 350 cc can remain in use up to 6 years; and large motorcycles exhibit an average lifetime of between 5 and 10 years. At these replacement rates, somewhat more than 75 percent of the field of smaller machines is renewed every 5 years, and at least a similar portion of large motorcycles are replaced in less than a decade.

Measurement Procedures

Since the noise level of any acoustic source can be meaningfully measured and recorded only with reference to a specified measuring technique, it becomes extremely important to establish a firm procedure when measuring or discussing motorcycle noise. Five such procedures exist (see Appendix B) which apply, in one way or another, to new motorcycles sold in the United States, and the noise level values obtained for any particular machine differ greatly between these procedures.

Only two of these procedures, however, are widely used in establishing vehicle noise levels for legal compliance, and almost all noise level data and familiarity with motorcycle noise is based on these methods. In the State of California, the California Highway Patrol (CHP) has established a vehicle noise measurement procedure applicable to motorcycles in which the maximum A-weighted sound pressure level is measured as the motorcycle accelerates past at a 50 foot distance in one of the lower gears under wide open throttle. This is the procedure used for new vehicle noise testing by California authorities. The Society of Automotive Engineers (SAE) Standard J331 – Sound Levels for Motorcycles – measures the same quantity under similar conditions except that the acceleration is arranged for individual machines so that maximum rated engine power will be achieved quite close to the test microphone. This arrangement has caused measured levels to be from zero to 10 dB greater than levels achieved by the same machine operating under the CHP procedure. Unfortunately, there is no straightforward relationship between values obtained with the two procedures. Studies accomplished during 1970–71 show the differences between SAE and CHP values which existed for various size machines of that period.[2,3] From this information, a conversion curve of dB with displacement can be obtained which represents the mean difference relationship for 1970 model machines.[4] Due to significant changes in motorcycle noise characteristics since that time which have been forced by state legislation, this relationship is not strictly valid for 1973 machines.[5] Thus, any conversion between SAE and CHP values for current models based on the 3 year old data will contain some degree of inaccuracy.

Nearly 80 percent of the noise level data obtained for this project were measured according to CHP procedure, the remainder being measured according to the SAE procedure. Although SAE results more closely approximate maximum noise, the interest of accuracy will be served by converting the 20 percent SAE data into its approximate CHP equivalent and presenting all noise levels as being obtained from the CHP test method. Based on interpretation of the 1971 data, it will be assumed that the CHP level is 2 dB lower than the SAE level for motorcycles under 400 cc displacement, and 4 dB lower for motorcycles of 400 cc and larger. This creates an uncertainty of approximately ±1.5 dB from true CHP method values.

The CHP and SAE test standards appear to have equivalent technical foundation, and measurements of motorcycle acceleration noise can be made with equal precision using either method. Hence, no lack of data quality was incurred by choosing the

CHP method for use in this project. As mentioned above, the SAE method allows achievement of maximum rpm consistently close to the microphone, and provides as accurate a measurement as has been devised for maximum possible noise (see Appendix B). Because the SAE procedure more closely measures motorcycle noise at an absolute level of performance (maximum rpm at wide open throttle), it might be the most objectively useful type of measurement for community noise assessment or regulation enforcement. Because lower noise level values are usually generated by the CHP method, it is more widely endorsed by industry. "Same-day" repeatability of both procedures is usually within 1 dB, but occasional consecutive measurements of the same machine differ by as much as 2 dB. During both the CHP and SAE procedures, accelerations of up to 0.3 g are produced. Although this level can be exceeded by some large displacement machines, it defines the maximum normal duty acceleration. In addition, as will be seen in the Cruise-By section of this chapter, a CHP method noise level may accurately indicate the maximum steady speed passby noise to be expected from a given machine during typical use. One inequity in both these methods is variable rider weight. Clearly, a machine burdened with an excessively heavy operator will accelerate more slowly than with a light rider, and will likely produce less noise during the test. Also, several "treatments" have been discovered which can be applied to any particular test vehicle to reduce its test noise level below that of a machine normally prepared for routine operation. Boiling the final drive chain in grease, using unusually heavy oil, providing abnormally high tire air pressure, and adjusting the fuel mixture to a "lean" condition will cause the machine to accelerate more slowly against less resistance, and is reported to reduce noise levels from a mechanically loud vehicle by as much as 3 dB. In summary, however, the SAE and CHP acceleration test methods appear equivalently repeatable, meaningful in terms of in-use noise levels, and acceptable to industry as a useful method for determination of the noise levels of individual motorcycles.

A-Weighted Noise Levels

Noise levels have been obtained for most popular 1973 models as measured with the California Highway Patrol test procedure. Reported noise levels obtained with the

SAE procedure have been converted using the previously described adjustments. All of the levels are displayed in Figure 2, with distinctions shown between motorcycles with two-cycle engines, four-cycle engines, and minibikes. Off road motorcycles not subject to registration are omitted. Noise level differences of up to 4.5 dB have been found between different machines of the same model. This noise level spread is similar to those of other vehicle types, and the data of Figure 2 represent the louder extremity of this quality control region. Thus, practically all of the individual vehicles represented by each point on the figure will be at or below the indicated noise level. The levels are as measured, with the 2 to 3 dB "tolerance" sometimes found in vehicle noise measurement procedures not applied, and represent vehicles as sold throughout the country. The noise level spread evident for all motorcycle size ranges results from differences in the configurations of engines, intake silencers, mufflers, and other noise sources on the machine which will be discussed in detail further on in this chapter.

It is seen how the high displacement portion of the region in Figure 2 tapers off roughly asymptotic to the 86 dBA level. Data from the previous years 1970-71[2,3,6,7,8] are distributed in a more linear manner, proceeding through the 86 dBA level and continuing through 95 dBA for the large machines. This difference indicates the high degree of noise control which has been effected, primarily on the large displacement machines and loudest small machines, since 1970. The values are not incidental, but reflect the requirements of the California Vehicle Code which has set the national pace in regulation of new-vehicle motorcycle noise by reducing permissible levels (for machines of over 15 horsepower) from 92 dBA for machines of pre-1970 manufacture, to 86 dBA for those of 1973-74 manufacture (see Appendix C). Almost all new motorcycles sold in the U.S. are equipped to meet this regulation. Consideration of Figures 3 and 4 reveals the same noise level trend whether engine displacement, maximum rated horsepower, or retail price is used as size discriminator – thus illustrating the close relationship between these quantities and justifying the use of engine displacement as a good size discriminator for noise control analysis.

Further examination of Figure 2 reveals an apparent noise level difference between two distinct groupings. Motorcycles of under 100 cc displacement show wide

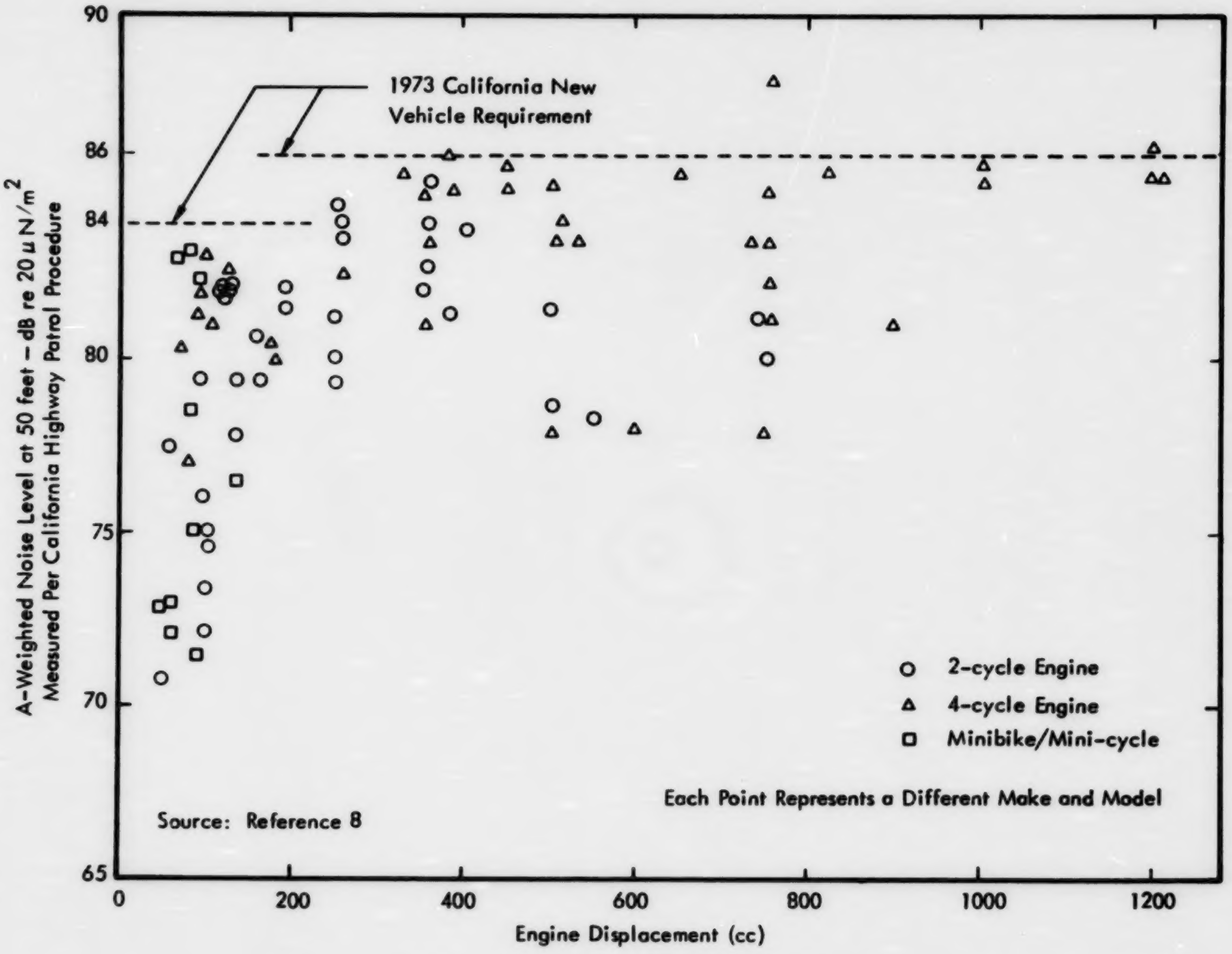


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Figure 2. Noise Levels of 1973 Model Motorcycles

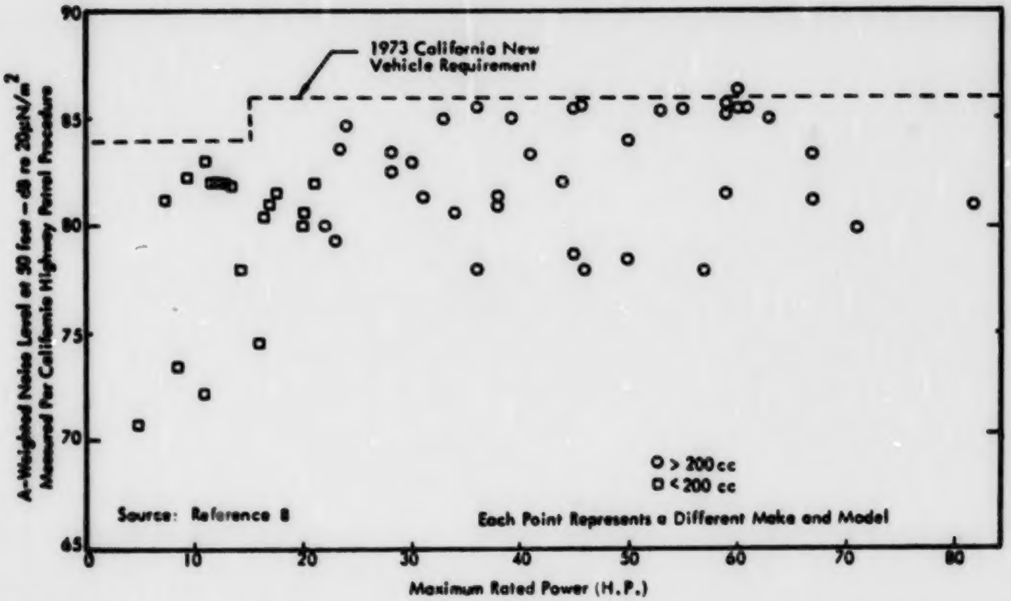


Figure 3. Noise Levels of 1973 Model Motorcycles

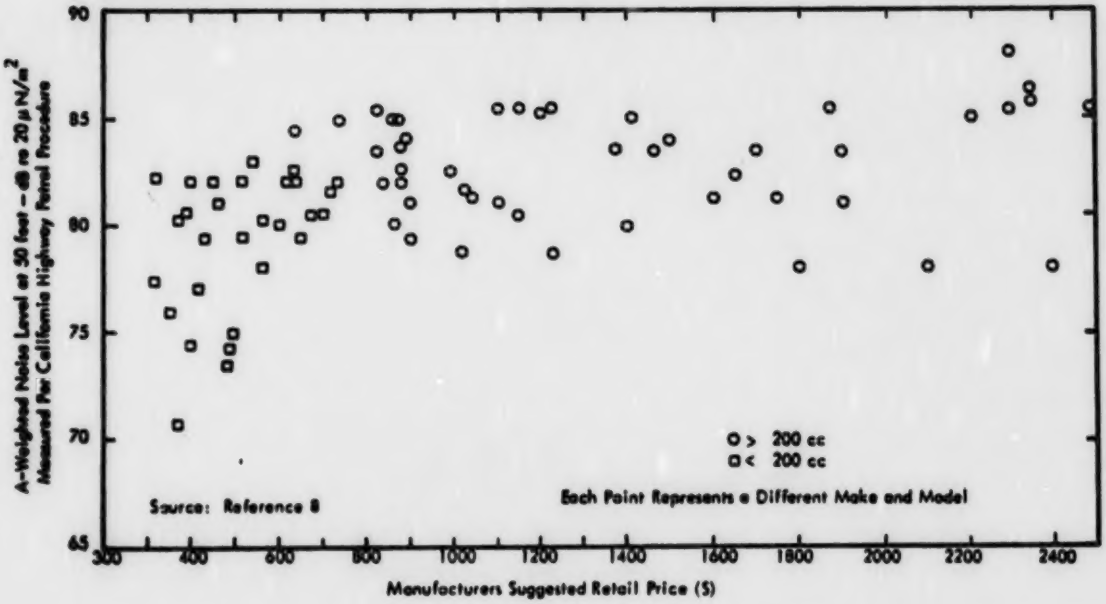


Figure 4. Noise Levels of 1973 Model Motorcycles

scatter in achieved noise levels, from 71 to 83 dBA, while models of 250 cc and above range from 78 to nominally 86 dBA. The 200 cc size represents the approximate transition between the "motorcycle" and "motor-driven cycle" as usually denoted in state vehicle laws and by the Society of Automotive Engineers.[9] Motor-driven cycles, defined in California as two wheelers of under 15 horsepower, are restricted from certain high speed roads and, in California, are subject to stricter noise requirements. Motorcycles, those of 15 horsepower or more, are afforded full vehicle status. The state of modern engine development is such that the 15 horsepower figure is usually attained by engines in the 150 cc to 200 cc range, and thus the below 200 cc category contains principally motor-driven cycles. These small machines are generally suitable for arterial, neighborhood or lower speed travel, while 250 cc or larger motorcycles may be operated easily at freeway speeds. Given the differences in noise levels, classification, and use of these groupings, discussion of noise levels in this report will consider machines larger and smaller than 200 cc separately, with additional comment on the exceptionally low noise levels of motor-driven cycles smaller than 100 cc.

Several additional considerations have become apparent from the acceleration noise level data. Foremost, and a matter of immediate curiosity to most motorcyclists, is the difference in noise level between vehicles powered by two-cycle and four-cycle engines. Figure 2 indicates, however, that little difference exists between the two. Throughout the 100 to 200 cc range, and for the popular 250 cc, 350 cc, 500 cc, and 750 cc sizes, the A-weighted sound pressure levels as determined by CHP procedure for the two engine types are well integrated, with no distinctive differences apparent. This fact must not be construed to mean that a listener's perception of the two sounds of equal noise level will be the same, for the differing frequency content of the noises will cause dissimilar tonal quality. In the under 100 cc range, all of the low noise level cycles (with the exception of minibikes) are two-cycle powered. This difference will be discussed in the following sections and chapters dealing with exhaust and mechanical noise.

Another prime matter of interest is the comparison of noise levels of dual purpose motorcycles to those of the highway variety. The question arises due to the traditional use of lightweight and noisier components on motorcycles intended for part-time off road use. Although not pictorially shown, 42 percent of the available data represents dual purpose machines, and again, no significant difference can be noted between the respective collective noise levels in any size range. Finally, attention is directed at the effects of the recent trend toward multicylinder engines. Three and four cylinder engines have become common since 1970, but once again, no detectable general difference between singles, twins, triples, and fours exists in the data.

Off road motorcycles not subject to registration, licensing, or police surveillance become a special case. Highly prone to individual post-purchase modifications complimenting owners' tastes, exhaust and intake systems are commonly replaced with various after-market units. In many cases, these accessory systems provide little silencing, and for this reason factory noise specifications for off road models do not truly indicate the noise levels of post-purchase vehicles. Unmuffled two-cycle powered off road machines can generate over 110 dBA during the CHP test, but areas where unmuffled operation is within the law are becoming extremely scarce (see Appendix C). Muffled levels from 80 dBA to 97 dBA, with most in the 90 dBA region, are typical. Due to the difficulty of assessing noise impact from off road vehicles, the difficulty in enforcing regulations more complex than the "adequate muffler" variety, and the performance requirement, off road motorcycles will not be included in the economic evaluation of noise control potential.

Minibikes are a final small category including less than 5 percent of recent two-wheeled vehicle sales. Noise levels range throughout the under 200 cc category noise level spread. Included in the above percentage figure are the once popular motor scooters, which represent less than 0.4 percent of total sales. The little noise level data which exists for motor scooters is within the range of under 200 cc noise levels, but too little noise or economic data has been obtained to allow their inclusion in the project analysis.

Cruise-By

Noise levels obtained with the CHP procedure lie somewhere between the maximum and minimum levels of which the tested machine is capable, the proportion between the two being a function of the test procedure.[10] It has been stated earlier that the CHP procedure usually yields noise levels below the maximum possible for a given machine. There also appears to be a relationship between CHP measurements and lower motorcycle noise levels. Figure 5 shows the difference between CHP method values and steady speed passby values at 50 feet for all motorcycle sizes. The shaded regions are uniformly represented by a distribution of noise data, and thus it is seen that 1973 model motorcycles operated in the lower speed range of 25 to 40 mph can be much quieter (5 to 25 dBA) than when measured during the CHP test. Also, even at maximum in-use speeds, constant speed noise levels still do not substantially exceed those determined by the CHP procedure, suggesting that the CHP standard may provide a good indicator of near-maximum levels generated by this mode of real life use. It should be mentioned that the function of steady speed noise level with speed for a particular machine does not necessarily monotonically rise. Speed increases of as much as 10 mph may have no effect on noise level, depending on motorcycle construction, and the use of higher gears can even show reductions in total noise level with speed gains.

Coast-By

Discussion of vehicle noise control often includes allusion to a noise "baseline" or "noise floor" — being the minimum possible noise level of an ideally silenced vehicle. Such descriptions can be highly misleading, and any mention of lower bounds must include exact specifications of the vehicle, its operation, measurement techniques, and all other applicable conditions. Such minimum levels for motorcycles are usually portrayed by unpowered passbys at 50 foot distance which include noise contributions from drive chain, tires, roadway excited vibration, freewheeling internal drive systems, and windage. Maximum total levels between 60 and 68 dBA have been recorded for

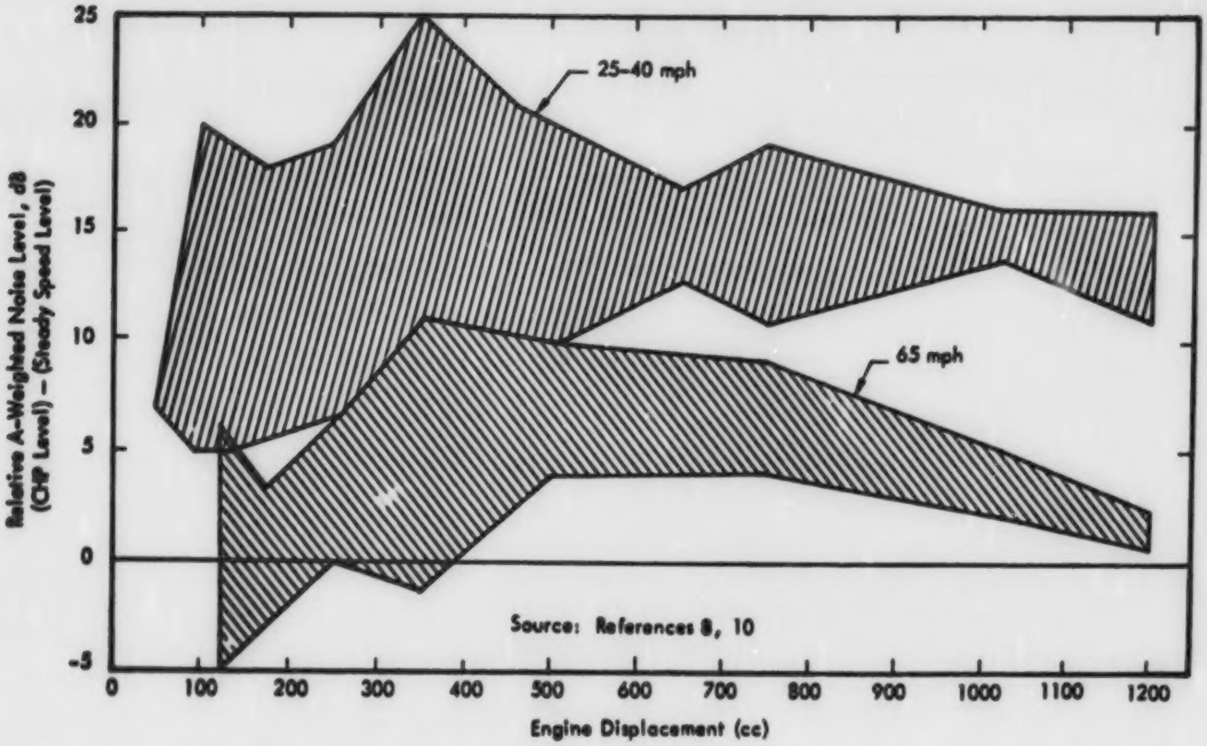
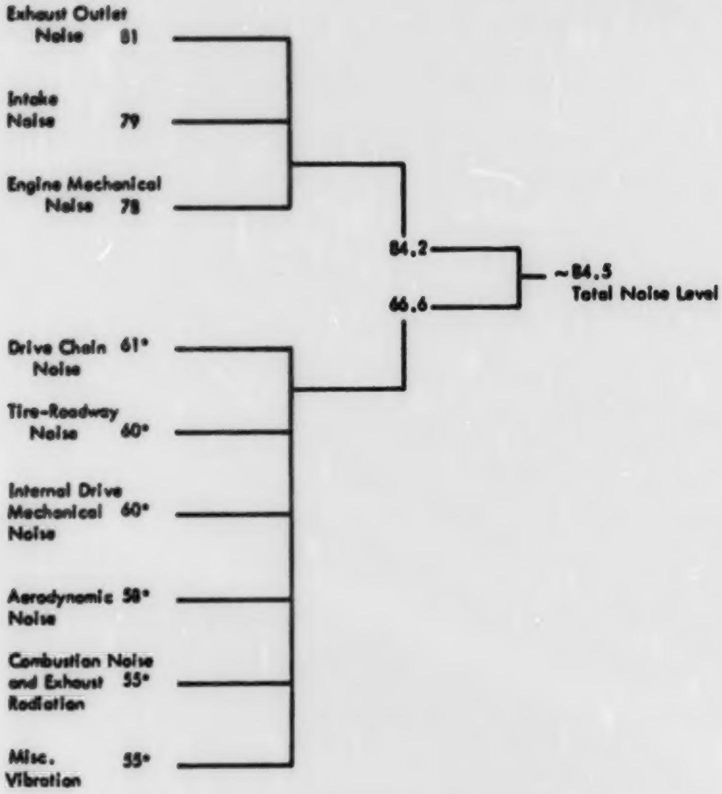


Figure 5. Difference Between CHP Method Acceleration and Steady Speed Noise Levels for 1973 Model Motorcycles

moderate speeds of 30 to 40 mph, but no well-founded portioning of this noise between the contributing sources has been accomplished. Estimates which have been made are included in Figure 6. It is likely that the combined level of these coasting noise sources is the same during powered passby, since all operate in the same mode with the exception of chain load reversal. Although reductions in coast-by noise could be accomplished through such devices as full chain cases, shaft drive, or solid wheels, the contributions of these sources is clearly negligible (see Figure 6) when compared to noise generated by the engine. Thus, consideration of "noise floor" levels is currently of little practical use in the reduction of noise from existing models.


Exhaust Outlet Noise 81
Intake Noise 79
Engine Mechanical Noise 78
84.2
66.6
~84.5 Total Noise Level
Drive Chain Noise 61*
Tire-Roadway Noise 60*
Internal Drive Mechanical Noise 60*
Aerodynamic Noise 58*
Combustion Noise and Exhaust Radiation 55*
Misc. Vibration 55*

* Values estimated by motorcycle manufacturers and Wyle Research .

Figure 6. Typical Component Contributions to Total Noise Level When Measured per California Highway Patrol Procedures (dBA at 50 feet) for Typical 1973 Model Motorcycles > 200 cc

Operator Noise Levels

Finally, noise levels experienced by motorcycle operators may be considered. Recent studies have demonstrated the high levels of noise present at the ear during exposure to airflow past the head.[11,12] For motorcycles, at-ear noise levels (measured at the ear with a small microphone) below 40 miles per hour vary with the type and operation of the motorcycle, and have been reported to be around 100 dBA at 20 mph. Above 40 mph, at-ear total noise levels become a function of speed alone, being completely determined by aerodynamic noises, although certain narrow frequency ranges of the machine radiated noise may still be apparent to the rider. Noise levels are reported at these speeds from 100 dBA at 40 mph to over 110 dBA at 70 mph. Use of protective safety helmets has been shown to cause moderate reductions of at-ear noise depending on speed, fit, style, and type of eye protection.[11] Still, the motorcyclist is constantly exposed to high noise levels by virtue of his unshielded passage through the air.

Noise Sources

As stated at the beginning of this section, the modern motorcycle is a complex noise generator, several exposed components of which contribute significantly to the total noise produced. These contributing vehicle elements are commonly called noise subsources. Typical contributions of various subsources to the total motorcycle noise level as measured by the CHP procedure have been shown in Figure 6. The values are not from any particular machine, but do represent typical component levels existing for 1973 model motorcycles of the over 200 cc category. Immediately apparent is the significance of exhaust outlet, engine intake, and engine mechanical noises, and the low importance of the other subsources which were principally included in the coast-by discussion.

Exhaust

Through an opened exhaust valve or port, an exhaust gas pulse with a temperature of several thousand degrees and a pressure of several hundred pounds per square inch enters the exhaust system in a matter of milliseconds. This large pressure near-discontinuity propagates along the exhaust system piping to exit at an amplitude determined by the system configuration. A running engine can repeat this process over a hundred times per second, with the resultant perceived noise appearing as a staccato or smooth tone depending on engine type and speed. As measured using the "A" weighting network of a sound level meter, unmuffled exhaust outlet noise alone can be over 110 dBA at 50 feet during a CHP acceleration test. Some of the very simplest mufflers consisting of a perforated tube surrounded by sound absorbing material will attenuate exhaust-only noise to below 95 dBA. Further reductions have required more extensive reactive muffling, and levels of 82 dBA for large highway machines to 70 dBA for under 100 cc machines are generated by the exhaust outlets of 1973 production models during the CHP test. It should be added that exhaust levels as low as 76 dBA are achieved using unusually large standard type muffling systems on some large displacement highway vehicles. For off road motorcycles, exhaust outlet noise has always been the predominant subsource, and recent muffler and spark arrestor requirements have caused a lowering of average exhaust noise levels to below 90 dBA for 1973 production models.

The great pressure differential across an exhaust pulse traveling along exhaust piping can excite the exhaust system walls into vibration which allows direct transmission of exhaust noise through the system walls. The exact contribution of exhaust wall radiation to CHP method total noise levels has not been determined. It is estimated that, although at present exhaust radiated noise is not a major contributor, its importance on some machines may increase as total noise levels are reduced.

Immediately apparent to a listener is the difference in tonal quality between two-cycle and four-cycle engined motorcycles. The origin of this difference must lie among the vehicle subsources, and of those, only the engine sources vary. Although disparity will be found between mechanical and intake noises from the two engine types, the primary difference accountable for the unique tonal interpretations is the exhaust. Figures 7 and 8 illustrate the characteristic difference in exhaust noise spectra. Figure 7 is a representation of exhaust-only noise as measured a short distance from the exhaust outlet of a muffled four-cycle motorcycle engine. The shape of the curve clearly corresponds to combustion exhaust characteristics, with most of the energy below 500 hertz, and slowly trailing off into the high frequency region. Figure 8 shows total passby noise as measured for an unmuffled two-cycle machine where exhaust noise is the only significant subsource. The trend of increased energy content at higher frequencies contrasts sharply with that of the four-cycle engine, and accounts for the higher pitched noise associated with two-cycle machines. Due to the differing test natures, the respective

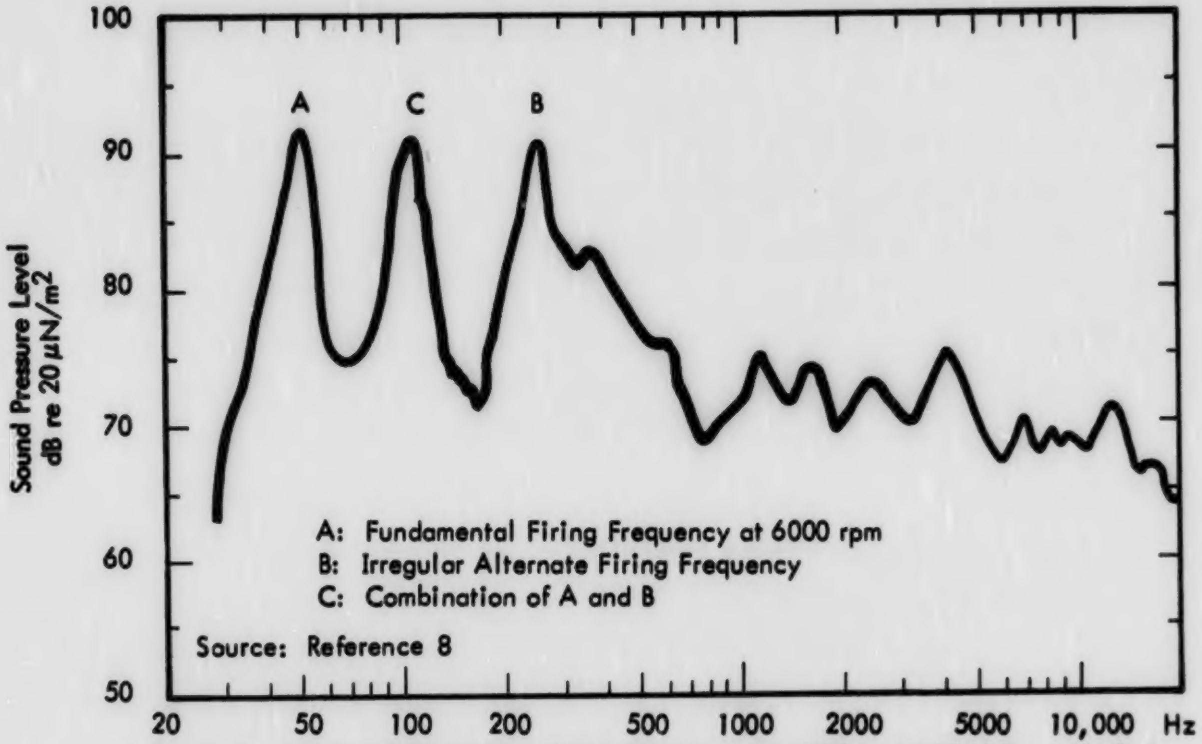


Figure 7. Narrow Band Exhaust Noise Spectrum for >200 cc Muffled Four-Cycle Twin Cylinder Motorcycle – See Text

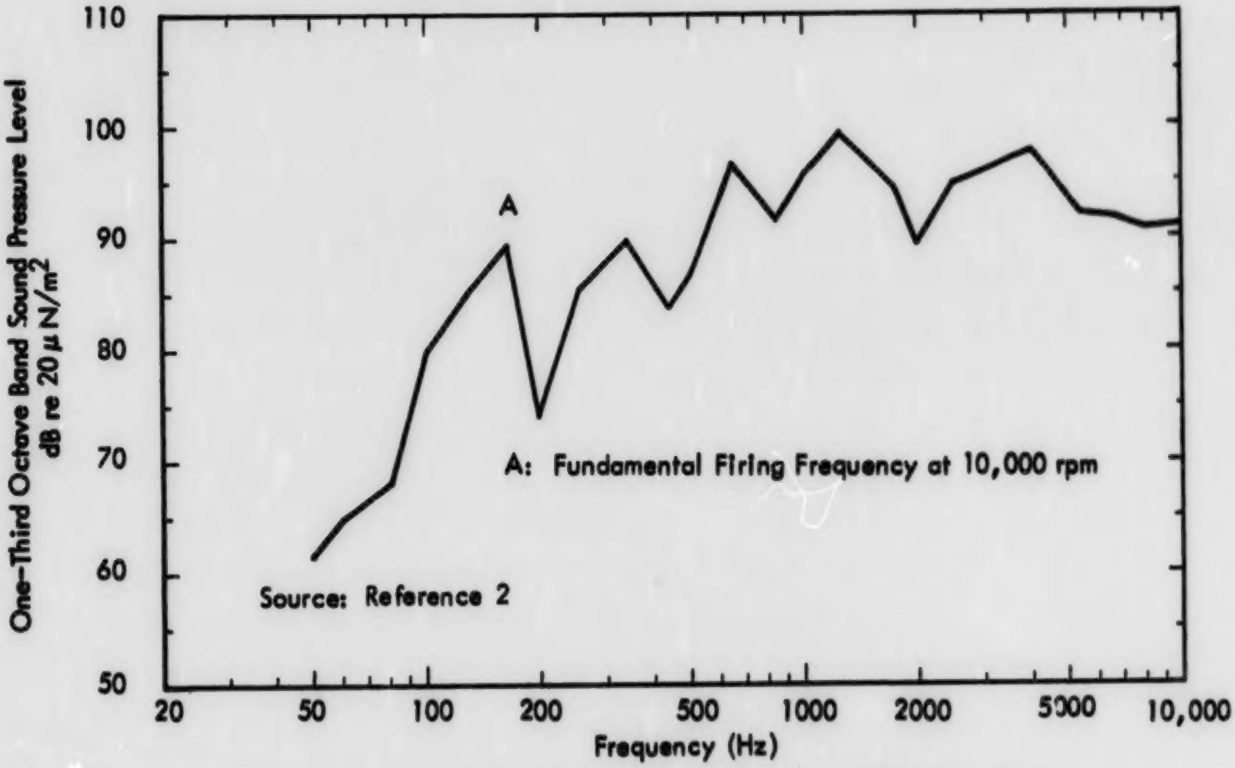


Figure 8. Passby Noise Spectrum for <200 cc Unmuffled Two-Cycle Single Cylinder Motorcycle – See Text

numerical levels indicated on the figures cannot be meaningfully compared. It is probable that some high frequency noise was already attenuated by the four-cycle muffler, thus causing the two curves to diverge more widely than in equivalent comparison. These small inaccuracies aside, the pertinent fact is that in each case exhaust noise was the principal quantity measured, and a clear difference is apparent.

Relating the discreet tonal interpretations of two-cycle and four-cycle motorcycle engines to irritability is difficult, for annoyance in this case is largely determined by variable physical and psychological factors. Even scientific measures of subjective noisiness which allow for frequency content and pure tones do not account for the sensory difference between the two engine types.[2] Thus, two motorcycles, even of the same engine type, with equivalent A-weighted sound levels can be perceived as of different loudness and quality, with attendant difference of irritation due to the dissimilarity of exhaust noise spectral distribution.

Intake

With the reduction of exhaust noise prompted by recent regulations, noise from the intake system soon assumed important levels, and for current models, the two subsources are of approximately equal noise level for all motorcycle sizes. They both correspond to throttle opening, engine speed, and load, and are the two predominant noise sources for most modes of operation. Although for over 10 years, some sort of air cleaner has been fitted to almost every standard machine, improved intake silencer designs have been required in order to produce current intake noise levels which range from 77 to 84 dBA for machines larger than 200 cc. Two-cycle engines which, for a given speed, induct nearly twice the volume of air as four-cycles of equal size, have traditionally generated high intake levels, but recent improvements in silencing practice have reduced these levels to those of the exhaust. Also, there is some indication that, as exhuast muffler "back pressure" increases, intake noise levels may also increase. Intake and exhaust mechanisms are the boundary elements of the general problem of flow through the propulsion assembly, and their close interrelation is the subject of many current theoretical and empirical investigations.

Engine Noise

As is characteristic of any vehicle propelled by an air cooled engine, a noticeable mechanical clatter and ringing accompanies the passage of most motorcycles. Although the contribution of mechanical subsources to the total noise level determined by the CHP test is difficult to measure, near field measurements have been made which allow estimates in the 68 to 80 dBA range. Mechanical noises directly transmitted from within the engine result from the actual striking together of engine parts, such as piston slap, valve and valve train clatter (present in four-cycle engines only), gear meshing, and noise from the roller and ball bearings widely used in motorcycle engines.[13] Secondary mechanical noise is that radiated from the vibrating engine surfaces, such as cooling fins and casings, which become excited by the aforementioned collisions of engine parts and combustion pulses. Industry sources have found this mechanical sound power to rise approximately with the fourth power of engine speed (12 dB per doubling of rpm). The common small engine noise source of flywheel windage and vibration appears to contribute very little. Directly transmitted combustion noise, a final source of engine noise, is considered by the industry to be of an insignificant level in relation to the major sources for most modes of operation. Thus it is principally the mechanical sounds which provide engine noise of level and tonal characteristics sufficient to vitally influence the total level and quality of a motorcycle's sound. Reduction of total motorcycle noise levels may require a disproportionate reduction of mechanical noise in order to produce a resultant sound sufficiently free from the "bolts in a can" effect.

Drive Noise

Drive noise is here considered to consist of noise from internal and external drive system components, and tire noise. Internal sources are of two categories, gearset and primary drive. Gearset noise originates with the meshing and movements of gears and bearings within the gear ratio assembly. The primary drive system, comprised of the clutch and chain or gear linkage between engine crankshaft and gear set, creates additional contact sounds which are at times complemented by vibration noise from clutch components. The total of these levels is generally lower, however, than that produced by the external drive chain, which itself is not an important contributor during the CHP test. The modern trend toward sporty vehicles has discouraged use of fully enclosed chains or shaft drive, thus maintaining final drive noise levels at a maximum. Of course, these drive system subsources assist in the excitation of external gearset cases, primary cases, and other vehicle parts which radiate additional sound. As stated earlier, coast-by levels of 60 to 68 dBA have been recorded, and considering the higher loading and vibration present under power, contributions of between 65 and 70 dBA might result from current power drive systems. Tire noise, a normally predominant component of total vehicle noise as speeds increase, is found among the minor motorcycle subsources. Due to the extremely small contact surface and relatively well damped sidewalls, tire noise, even at high speeds, ranges near 60 dBA. Off road "knobby" tread types, when used on pavement, have been noted to raise tire noise levels 1.0 to 1.5 dB above those of highway tires, but such increased levels would still not become important until total levels are reduced below 75 dBA. In any case, highway use of these louder tread patterns will not become widespread due to extremely high wear rates and reduced traction.

Aerodynamic and Miscellaneous Noises

Aerodynamic noise, that caused by the turbulent passage of air in and around the motorcycle components and rider, may become more significant than 58 dBA (indicated in Figure 6) as speeds increase. Spoke tip speeds of greater than 100 feet per second with respect to oncoming airflow are achieved at freeway speeds. Such sources, combined with the dominance for the operator of wind noise at high speeds, indicate that high speed chainless coast-by tests might show surprisingly high aerodynamic/tire noise levels. Radiation of noise from remaining motorcycle components such as fenders, fuel tank and side panels due to the various engine, drive, and road excitations is difficult to quantify except by process of elimination. In this way, the level entered in Figure 6 has been developed to closely represent the noise originating from these components on an average 1973 machine.

Noise Source Relationships

The absolute levels and ranking of subsources shown in Figure 6 are representative contributions to the maximum acceleration noise as measured by the CHP procedure. For other modes of vehicle operation, the relative prominence of the subsources may change. During acceleration, intake and exhaust noise are at their peak since they correspond directly together to throttle opening and load. Partial throttle closure to a steady speed will cause a de-emphasis. Engine and vibration noises then assume more importance and, at proper speeds, can effectively mask intake and exhaust. Thus, along with a change in total noise level, the tonal quality of the machine's sound changes with the operating mode, and can give rise to further virtual or perceived changes in "noisiness." Several instances have occurred where, when comparing the noise of two motorcycles, observers have judged the machine with the lower A-weighted noise level to be the noisier of the two. Thus, quieting of a motorcycle does not exclusively imply a lowering of total sound pressure level, but can in some cases be achieved through tonal modifications, while retaining a tone which renders the machine desirable to the consumer.

Noise source relationships may also change with vehicle use. Little data exist which show noise level changes of properly maintained motorcycles with mileage accumulation. One investigation, however, did note a significant increase in the level of a new 250 cc two-cycle off road machine. Initial acceleration noise levels of 85 to 86 dBA were increased to 96 dBA after a few hundred miles of severe off road use, the increase apparently divided between exhaust and mechanical noise. This lone example cannot be considered to represent typical noise level changes with use, but does confirm that transpositions of noise subsource importance, as well as total noise level increases, are possible.

5. SELECTED NOISE LEVELS

Introduction

The 1973 models for which noise levels are shown in Figure 2 can be conveniently grouped into two general classes, representing two distinct engine size ranges. As explained in Chapter 4, the operating characteristics of these classes separate near an engine displacement of 200 cc. Furthermore, noise levels of the smaller machines with engine displacements less than 200 cc again naturally divide into two regions, namely 0 to 100 cc and 100 to 200 cc. Figure 2 illustrates a proven industry ability to achieve uniquely low levels for motorcycles in the 0 to 100 cc range, and so this size category will be considered independently in the assessment of noise reduction capability. Machines of the 100 to 200 cc class, although generating noise levels similar to those of very large motorcycles, are often similar in construction and operation to the smallest category. In fact, this 100 to 200 cc size range is a transition region containing machines of large, small, and heterogeneous character, and thus noise reduction abilities will also be determined separately for this range. The discussion of noise control feasibility, then, will distinguish as far as possible between technology for the following classes:

- Class 1 – 0 to 100 cc
- Class 2 – 101 to 200 cc
- Class 3 – over 200 cc

The discussion of present and future noise levels of these three classes can be facilitated by concentrating on a few representative levels. It has been decided , in consultation with the EPA[14] that three different noise levels will be examined for each motorcycle class based on the information and data supplied by the manufacturers. The three levels may be summarized as follows:

- Level 1 – Typical level of the quietest 1973 models
- Level 2 – Level of the most quiet product which could be available in October 1975, using all known or shortly available technology

- Level 3 – A level somewhere between the first two, if widely divergent, representing a practical industry goal for October 1975 using available technology.

In Chapter 4 it was stated that noise levels from different vehicles of the same make and model can differ by as much as 4.5 dB. Thus, in order to insure that all machines of a specific model will exhibit noise levels below any given figure, many factories attempt to achieve an average level for the model approximately 2 dB below the goal figure. Considering this practice, and the fact that the noise levels of Figure 2 represent loudest production examples, the selected levels herein defined will be achievable for almost all machines in each model line indicated as being able to meet these levels.

It must be recognized that there exists in the motorcycle industry a diversity of "character" provided by the varied approaches adopted by different factories to the basic motorcycle concept. Machines of quite diverse basic style and design are available, from huge V-twins to small three cylinder two-strokes, and the "personalities" of several of these arrangements represent decades old traditions. The experienced motorcyclist can immediately sense, for example, English, Japanese, or Italian flavor in a motorcycle's styling, its sound, its ride, or even the form of a single part. Hence, the noise level values developed in this section must be average interpretations of this wide range of machinery. The remainder of this section presents the rationale for the establishment of the selected noise levels for each vehicle class. A discussion of specific noise reduction techniques is presented in Chapter 6.

Level 1

The first level is representative of the best well established noise control technology existing for the 1973 model year, and indicates where the industry stood in terms of noise control at the start of this project.

For Class 1 vehicles (0 to 100 cc), noise levels which extend below 75 dBA are principally for mini-cycle vehicles which constitute less than 25 percent of the Class 1 sales market and offer characteristically lower performance than standard Class 1 motorcycles. The groupings of noise levels above 80 dBA represents approximately 50 percent of the Class 1 vehicles sold; these being mainly powered by four-cycle engines. The distribution of the remaining machines with noise levels between 75 and 80 dBA, powered mainly by two-cycle engines, is fairly even. Thus, Level 1 is established at 79 dBA as representative of the best well demonstrated level of noise control for existing vehicles taking into consideration the higher noise levels evident for four-cycle machines.

An abrupt difference is seen for Class 2 vehicles (101 to 200 cc) where no noise levels are below 76 dBA. In fact, very few are below 80 dBA, and 81 dBA represents Level 1 for this class, the lower limit for well-established levels.

For Class 3 vehicles (greater than 200 cc), a quite distinct lower level is apparent and separate from the main data body, representing advanced and special machines atypical of the class. A level 1 of 82 dBA is the lower bound representative of the majority of the large machine field.

Level 2

The second level, that of the quietest possible product which could be available in 1975, is based upon liberal application of the available noise control technology to the quietest of existing machines without eliminating the basic performance characteristics.

Noise levels of quiet Class 1 vehicles presently lie between 71 and 75 dBA. Since the principal difficulties which manufacturers encounter in reducing noise lie with the larger machines, most previous subsource analyses and noise control activities have not been directed toward vehicles in Classes 1 and 2. Furthermore, given the extremely low minimum noise levels already achieved, which approach coast-by levels, the indication is that saleable, production motor-driven cycles with noise levels less than 70 dBA could not be manufactured by the date of interest. In one case a noise level of 68 dBA has been achieved with intake and exhaust silencers of disproportionate size together with fully enclosed drive chain and mechanical treatments, but only with excessive degradation of operating characteristics, which industry believes would seriously limit marketability. Thus Level 2 for Class 1 vehicles is established at 70 dBA.

This represents an absolute minimum for the class, is a full 10 dBA below present levels of the class' main body, and would not be achieved by more than 25 percent of Class 1 machines by the date of interest.

In Class 2, one minibike already exists with a noise level near 76 dBA, and several other standard machines are at or below 80 dBA. Thus, it is reasonable to expect that, given the noise reduction discussions of Chapter 6, the capability exists to produce standard machines with a Level 2 of 76 dBA by the date of interest. For Class 3 vehicles, two manufacturers currently produce models (representing about 2 percent of the market) with noise levels of 78 dBA. The remaining manufacturers have yet to develop or prove the reliability of prototypes with noise levels of 80 dBA. The noise level reductions required from the various subsources to achieve a total noise level of 80 dBA have been established, but specific design modifications are still experimental in most cases. It is also unlikely that further significant reductions could be available by October 1975 for the 78 dBA machines through improvement of the treatments which are to be described in Chapter 6. Rather, extension of these available techniques to the principal field of noisier machines for compliance with impending state regulations will consume manufacturer activities. Thus, the lack of available technology to achieve levels below 78 dBA, together with the belief expressed by several principal manufacturers that this level represents the minimum possible for Class 3 machines establishes Level 2 at 78 dBA.

Level 3

Level 3 indicates the noise levels which could be attained by the principal body of machines by October 1975.

Although the ability to produce Class 1 machines with noise levels in the 72 to 73 dBA region has been demonstrated, Level 3 is selected as 76 dBA, since demonstration of the lower levels has been achieved only for motorcycles powered by two-cycle engines. Approximately half of the Class 1 range of machines are so powered, and design similarities render it reasonable to expect that all such vehicles could meet the 76 dBA level by October 1975. The other half of Class 1 vehicles, propelled by four-cycle engines, appear to suffer a lack of available technology to reduce mechanical and exhaust noises characteristic of this engine type. Thus not all of these vehicles can be expected to achieve the 76 dBA level by the date of interest. One 90 cc four-cycle model currently exists with a noise level of 77 dBA, and other four-cycle powered mini-cycles have noise levels below 75 dBA. From this indication, and the specific considerations of noise control in Chapters 4 and 6, it is reasonable to expect that roughly half of the existing four-cycle machines with noise levels greater than 80 dBA can be reduced to 76 dBA by the target date. These vehicles, when combined with the two-cycle powered machines which should virtually all be capable of achieving 76 dBA constitute an estimated achievement potential of 75 percent of all Class 1 machines which could attain Level 3 of 76 dBA by October 1975. Selected noise levels have been developed for Class 1 as a whole since insufficient specific subsource noise level and cost data has been accumulated for Class 1 vehicles to allow separate noise level analyses for two- and four-cycle powered machines.

For Class 2 vehicles, the level of 80 dBA has been attained by both two- and four-cycle machines. Moreover, noise level data from the two engine types is more homogeneously distributed, indicating an equivalence of available noise reduction technology. As described in the introduction to this chapter, Class 2 represents a transition region in which individual vehicles have construction, operation, and noise characteristics which can be similar to those of either Class 1 or Class 3 machines. Thus, Level 3 should represent a goal attainable by both types of Class 2 vehicles. From Figure 2 it is seen that the minimum noise level already attained by both large and small Class 2 machines is 79 dBA, and therefore Level 3 is selected at 79 dBA. Approximately 90 percent of the 1973 Class 2 vehicles currently have noise levels above 79 dBA, and it is reasonable to expect that, of these, at least those with principally Class 1 characteristics could be reduced to 79 dBA by the target date. This would result in approximately 55 percent of all Class 2 vehicles meeting Level 3. It is also expected that nearly half of the larger style Class 2 vehicles could be reduced to 79 dBA, yielding a total estimated potential compliance to Level 3 of approximately 75 percent of all Class 2 vehicles.

Considering Class 3 motorcycles, a noise level of 82 dBA as measured by the CHP procedure would constitute a conservative goal, with over 50 percent of the industry possessing good achievement potential by October 1975. However, manufacturers involved in about 20 percent of U.S. sales claim a demonstrated ability to achieve the 1975 California regulation of 80 dBA with prototype or experimental Class 3 machines, and the remaining manufacturers are in the midst of intensive test and development programs oriented toward this goal. The machines currently produced with noise levels below 80 dBA constitute only 2 percent of current sales and contain unique design qualities to reduce mechanical noise levels which normally become significant at or about a total noise level of 80 dBA. Thus, on the basis of prototype achievements, industry orientation, and available technology, 80 dBA is selected for Level 3. This level should be within reach for almost half of the 1976 model Class 3 machines with concentrated development.

The three selected noise levels for each of the motorcycle size classes are listed in Table 3 on the following page.

The target date of October 1975 has been chosen to facilitate quantification of industry noise reduction potential and to conform to requirements set forth in the "Noise Control Act of 1972." Considering instead a date of October 1976, selected Levels 2 and 3 could be attained by higher percentages of the market. Level 2, which constitutes the lowest levels possible in 1975, would not be significantly lowered, but could be more widely achieved by all size classes. Level 3 would also be more feasible. It has been estimated that about 75 percent of the Class 1 machines could achieve Level 3 by October 1975, and that this would require application of improved mechanical and exhaust noise reduction methods for four-cycle powered vehicles. Assuming a continued

Table 3

Selected Motorcycle Noise Levels[1]

Selected Noise Level[2]	Size Class		
	Class 1 (0 to 100 cc)	Class 2 (101 to 200 cc)	Class 3 (>200 cc)
Level 1	79 dBA	81 dBA	82 dBA
Level 2	70 dBA	76 dBA	78 dBA
Level 3	76 dBA	79 dBA	80 dBA

[1] Noise levels measured according to the California Highway Patrol motorcycle noise measurement procedure (see Appendix B and text).

[2] See definitions of Selected Noise Levels, Page 29.

ability to apply these new techniques to more four-cycle models, it is likely that over 80 percent of the Class 1 machines could attain Level 3 by October of 1976. It has also been estimated that 75 percent of Class 2 vehicles could be produced with noise levels at or below Level 3 by October 1975, and that this would require improved techniques of reducing noise from those Class 2 vehicles which have physical and noise characteristics similar to those of the larger Class 3 vehicles. Assuming continuing ability to apply these new techniques to large style Class 2 motorcycles, it can be expected that over 80 percent of these machines could meet Level 3 by October of 1976. For the large displacement Class 3 motorcycles, it has been estimated that approximately 50 percent of the vehicles available in October 1975 could, through concentrated effort, meet Level 3 without extreme performance degradation. Even including an extra year, it cannot be predicted at this time that the percentage achievement would be much greater in 1976. However, approximately half of the industry is now able to achieve Level 3 with modifications which also result in serious decreases in maneuverability and performance. In view of this, it is reasonable to expect that greater than half of the machines available in 1976 could attain Level 3 with some significant reductions in all phases of performance. The consumer desirability of such machines is estimated by the industry to be quite low. Thus it is seen that, especially for motorcycles with engines smaller than 200 cc (constituting about 40 percent of all motorcyles sold in the United States), Levels 2 and 3 would be attainable by somewhat higher percentages of the market by October 1976.

6. NOISE REDUCTION TECHNIQUES AND COSTS

In the preceding chapter, three selected noise levels were developed for each motorcycle size class. This chapter will first present methods for achieving reductions from individual motorcycle noise sources. The cost of applying this technology to achieve the three selected noise levels for each vehicle class will then be developed through examples of average 1973 machines.

Noise Reduction from Subsources

The following motorcycle noise subsources will be discussed in this section:

- Exhaust
- Intake
- Engine and Mechanical
- Aerodynamic and Tires

For each of these subsources a brief description will be given of applicable noise control techniques, followed by a numbered listing of these techniques and a chart giving the associated increase in manufacturing costs. These costs have their basis in engineering consideration of general industry data which relate absolute or percentage costs to degrees of total noise reduction. The allotment of these group costs among the various individual subsource modifications was accomplished by evaluation of the difficulty of physically effecting the different modifications using:

- Past and present industry predictions of noise reduction costs for certain modifications to specific models
- Recent industry estimates of general costs for noise reduction of specific motorcycle types
- Prototype examples of noise reduction costs which could be checked directly using parts and labor estimates for existing machines.

Established noise reduction costs which have accompanied previous quieting of production machines were checked with the new information and found to roughly define a lower bound for the predicted future costs.

The industry data comprising the foundation of this analysis has been supplied principally by the five main motorcycle manufacturers who produce nearly 95 percent of all motorcycles sold in the United States. It is our opinion that the cost information provided by these manufacturers substantially represents industry expectations. Other data from smaller suppliers or accessory manufacturers has been incorporated whenever appearing reasonable and somewhat consistent.

Exhaust

Most of the early successes in noise reduction that were achieved after the introduction of local vehicle noise regulations involved improvements in exhaust silencing. Techniques using larger volume, more restrictive sound baffles in the mufflers, multiple mufflers, and the interconnection of header pipes on multicylinder engines have reduced exhaust outlet noise to current levels. For large highway machines of both the two- and four-cycle variety, further reductions of 2 to 5 dB in exhaust outlet noise, as generated during the CHP procedure, will involve a 30 to 100 percent increase in the volume of the exhaust system, requiring up to 30 pounds additional weight, and more effective baffling. Radiation of noise from exhaust system walls will also need to be considered. In one manufacturer test, covering the exhaust walls with thermal-shrink tubing caused near-field reductions in wall radiation noise level of from 6 to 8 dB. Thermal-shrink tubing is not practical for use on production machines, but many manufacturers are planning exhaust systems with double construction damped walls filled with acoustically absorptive material to reduce exhaust system wall noise radiation.

Although initial improvements in muffler technology in some cases increased engine power output, while at the same time providing additional silencing, such benefits with noise reduction can no longer be expected. The use of internal absorbing materials, double walled header pipes, and additional baffling in the above mentioned larger systems may provide reductions in exhaust noise of up to 8 dB from present levels, but consistent demonstration of this has not been achieved. New muffling concepts have recently been demonstrated in the after-market motorcycle muffler industry, involving the use of silicone elastic components and radial outlets. Manufacturers have demonstrated reductions of exhaust-only noise on highly sensitive two-cycle racing machines from over 100 dBA to the range of 76 to 82 dBA (depending on engine size) by merely fitting such silencers to the vehicles' open tuned exhaust systems. Net changes in engine power output are less than 5 percent positive or negative depending on the operating range. This type of silencer is currently being specified as original equipment on several dual purpose and off road machines, and further development may permit a more effective and cosmetic application to highway vehicles.

As described in Chapters 4 and 5, for Class 1 machines (< 100 cc), a clear difference in achieved noise levels between two-cycle and four-cycle powered vehicles is apparent. This may be due in part to the difference in exhaust noise spectrum noted in Chapter 4. The higher frequency nature of two-cycle engine exhaust noise renders it more easily attenuated by motorcycle-size reactive mufflers.

In summary, the most promising techniques for future reduction of exhaust noise, considering available technology, reliability, and industry familiarity, are as follows:

1. Muffler volume increase of 50 to 100 percent
2. Simply modified muffler baffles
3. Use of elastic components and radial outlets
4. Double wall construction of headers and mufflers
5. Increased and more constrictive muffler baffling.

The progressive application of these techniques to machines with typical 1973 noise characteristics is necessary in order to achieve the three selected total noise levels. The estimated costs of applying the techniques, together with the corresponding approximate noise reductions, are shown generally in Figure 9, and specifically in Table 4 for reduction to the three selected noise levels.

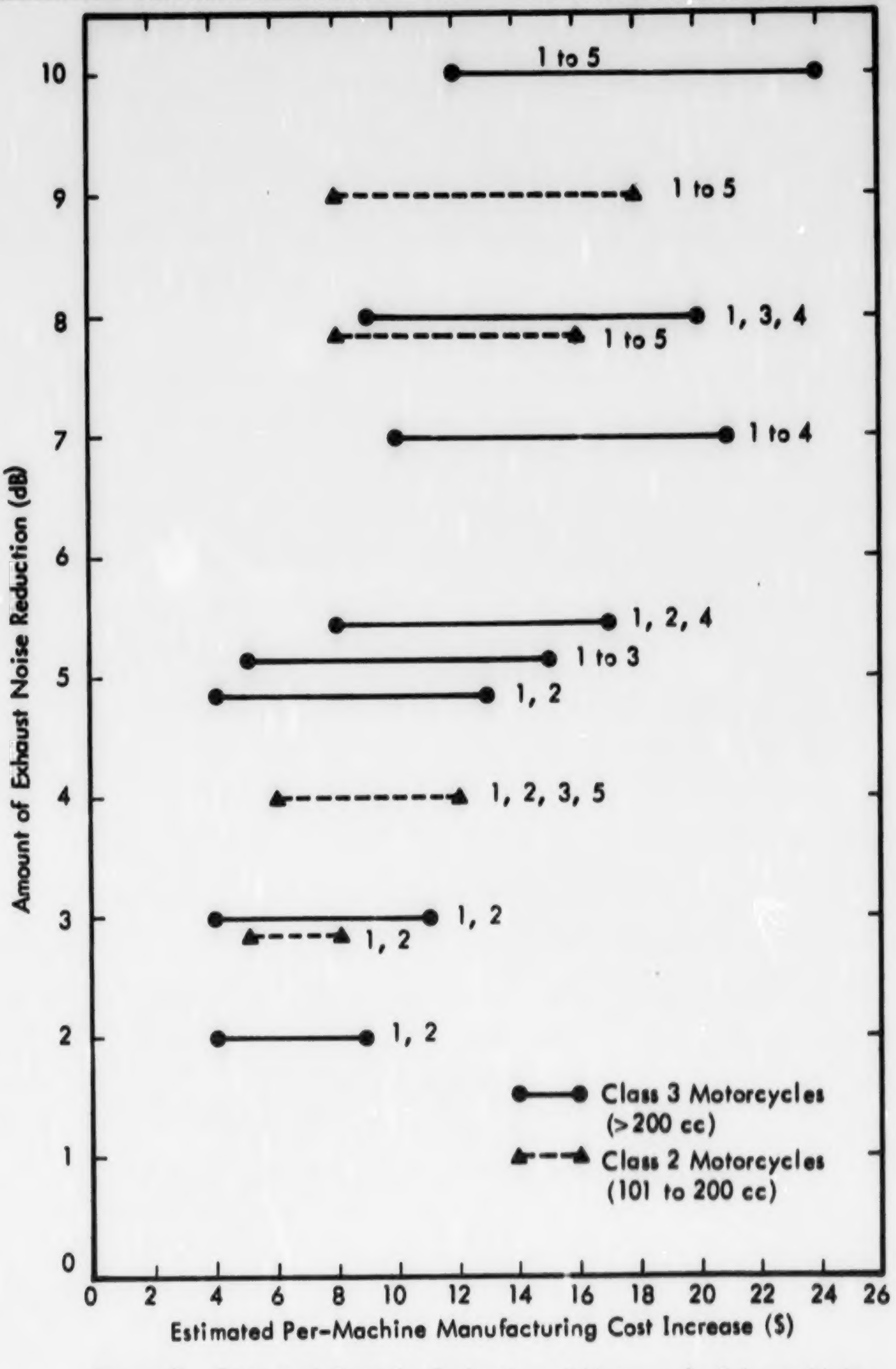


Figure 9. Estimated Costs for Reduction of Motorcycle Exhaust Noise

- Insufficient noise level/cost data exist for inclusion of Class 1 (< 100 cc) motorcycles.
- These estimated cost ranges are for typical example modifications to various machines of average 1973 noise characteristics as summarized in Tables 7, 8 and 9.
- Numbers represent noise control techniques listed in text.

Table 4

Required Exhaust System Modifications and Associated Costs to Achieve the Selected Noise Levels

Selected Noise Level	Machine Class	Average Exhaust Noise Contribution (CHP Test Method)[1]	Maximum Modifications Required[2]	Per-Machine Estimated Manufacturing Cost Increase[3]
Typical 1973	Class 1	—[4]	—[5]	—[5]
	Class 2	∼78 dBA	—[5]	—[5]
	Class 3	77 to 82 dBA	—[5]	—[5]
Level 1	Class 1	—[4]	—[4]	$0 to $2[6]
	Class 2	∼75 dBA	1, 2	$5 to $8
	Class 3	75 to 77 dBA	1, 2, 3	$4 to $15
Level 3	Class 1	—[4]	—[4]	$0 to $3[6]
	Class 2	∼74 dBA	1, 2, 3, 5	$6 to $12
	Class 3	74 to 77 dBA	1, 2, 3	$4 to $15
Level 2	Class 1	—[4]	—[4]	$1 to $5[6]
	Class 2	∼70 dBA	1, 2, 3, 4, 5	$8 to $18
	Class 3	∼72 dBA	1, 2, 3, 4, 5	$8 to $24

[1] These exhaust noise level ranges are those required to achieve the Selected Levels with typical 1973 machines when combined with the necessary intake and mechanical subsource noise levels developed elsewhere in this section.

[2] Numbers represent noise control techniques listed in text.

[3] All costs are increases from mid-1973 manufacturing costs including direct and indirect labor and materials, and engineering and development.

[4] Insufficient data exist to accurately determine average subsource noise levels for machines smaller than 100 cc.

[5] Not applicable.

[6] Costs for under 100 cc machines are estimated from cost projections for total noise reduction provided by industry.

Intake

The reduction of intake noise is effected in a manner similar to that employed for the exhaust, and has played a fundamental part in the recent lowering of total noise levels. Techniques such as the reduction of the inlet cross-sectional areas to the minimum required for adequate intake supply, the use of noise baffles along the intake tract, large rubber enclosed plenum volumes along the intake tract, and positioning of inlet apertures behind filtration elements in acoustically shielded portions of the machine have been used to achieve current intake noise levels. Reductions to levels below 79 dBA can be obtained by providing more complete inlet aperture enclosures, more extensive internal baffle systems, double walled container structures, a greater increase in system volume and additional acoustically absorptive material. One manufacturer expects that in order to achieve a total Class 3 vehicle noise level of 75 dBA, intake filter/silencer volume will need to be increased fourfold from 1973 sizes, which will require entirely new spatial configurations and changes in the vehicle frame. No new concepts or techniques are anticipated which will ease these basic intake silencing requirements. Thus, it is expected that these methods for reduction of intake noise will be more extensively applied to coming models. The methods of intake noise reduction are summarized below:

6. Minimize inlet aperture cross-section
7. Add plenum chamber to intake tract
8. Add internal baffles to intake tract/silencer
9. Shield inlet aperture behind special barriers or other motorcycle parts
10. Increase intake tract volume (including plenum volume) 50 to 100 percent
11. Double construction of intake system walls
12. Apply acoustically absorptive materials in addition to air filtration elements.

The estimated costs of applying these techniques, together with the corresponding approximate reductions in intake noise are shown generally in Figure 10 and specifically in Table 5 for reduction to the three selected noise levels.

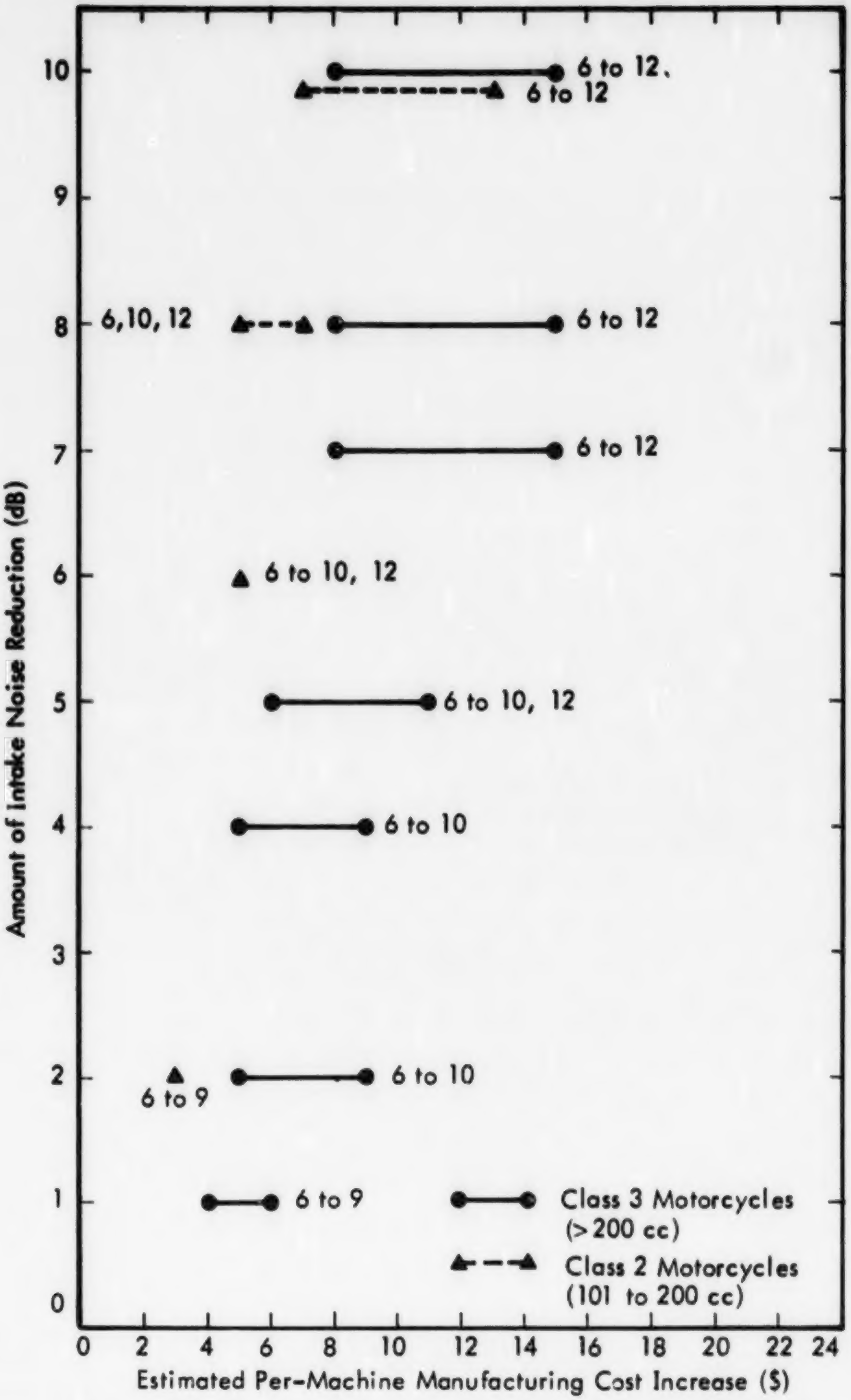


Figure 10. Estimated Costs for Reduction of Motorcycle Intake Noise

- Insufficient noise level/cost data exist to include Class 1 (0 to 100 cc) machines.
- These estimated cost ranges are for typical example modifications to various machines of average 1973 noise characteristics as summarized in Tables 7, 8 and 9.
- Numbers represent noise control techniques as listed in text.

Table 5

Required Intake System Modifications and Associated Costs to Achieve the Selected Noise Levels

Selected Noise Level	Machine Class	Average Intake Noise Contribution (CHP Test Method)[1]	Maximum Modifications Required[2]	Per-Machine Estimated Manufacturing Cost Increase[3]
Typical 1973	Class 1 Class 2 Class 3	—[4] ~80 dBA 77 to 82 dBA	—[5] —[5] —[5]	—[5] —[5] —[5]
Level 1	Class 1 Class 2 Class 3	—[4] ~78 dBA 77 to 79 dBA	—[4] 6, 7, 8, 9 6, 7, 8, 9, 10	$0 to $2[6] ~$3 $4 to $9
Level 3	Class 1 Class 2 Class 3	—[4] ~74 dBA 74 to 78 dBA	—[4] 6, 7, 8,9, 10, 12 6, 7, 8,9, 10, 12	$0 to $3[6] ~$5 $5 to $11
Level 2	Class 1 Class 2 Class 3	—[4] ~72 dBA ~72 dBA	—[4] 6, 7, 8, 9, 10, 12 6, 7, 8, 9,10,11,12	$1 to $6[6] $5 to $7 $6 to $15

[1] These intake noise level ranges are those required to achieve the Selected Levels with typical 1973 machines when combined with the necessary exhaust and mechanical subsource noise levels developed elsewhere in this section.

[2] Numbers represent noise control techniques listed in text.

[3] All costs are increases from mid-1973 manufacturing costs including direct and indirect labor and materials, and engineering and development.

[4] Insufficient data exist to accurately determine average subsource noise levels for machines smaller than 100 cc.

[5] Not applicable.

[6] Costs for under 100 cc machines are estimated from cost projections for total noise reduction provided by industry.

Intake and exhaust flows are of similar and related character, and thus the two noise sources are generally treated similarly and simultaneously. The paths for movement of gasses into and out of the engine also become paths for the escape of sound. The difficulty, then, is constructing a system which will not pass the sound, but which will pass the required gasses with little flow restriction. Appropriate balance between the acoustical and flow performance of the two systems is required for optimum engine performance with minimum noise. It has been suggested, for example, that intake noise increases with increasing exhaust "backpressure." The intake/exhaust modifications which have been effected since 1969 are reported to have reduced maximum power outputs for some large and small machines as much as 5 percent while providing the bulk of noise reduction achieved. Experimental vehicles have demonstrated further noise reduction capability through additional intake/exhaust changes (see Appendix D). One powerful 750 cc machine was lowered from 84 to 78 dBA, as measured per CHP procedure, by the addition of a large truck type intake silencer and extensive muffling. Similar reductions involving unusually large components are obtainable for Class 1 and 2 machines. Power and performance losses are almost exclusively due to intake and exhaust changes which increase intake and exhaust flow resistance and disrupt system acoustic tuning. Total noise levels in the range 78 to 80 dBA are widely believed to be the limit for noise reduction of large machines through intake and exhaust treatment alone. At lower noise levels than this, the contribution from the engine is, in most cases, equal to or greater than that from the exhaust and inlet combined.

Engine and Mechanical

To reduce total noise levels below about 82 dBA for the majority of larger machines requires curtailment of mechanical noise from both engine and drive system components. For conventional engine designs, little success has generally been achieved by limiting engine part working clearances, and for the high specific output motorcycle engine, reliability is jeopardized. Attempts to date at limiting mechanical noise have reduced total noise levels less than 2 dB, and have included items such as cast-in or rubber damping webs between cooling fins, staggered casting of fin surfaces, addition of stiffening ribs in engine covers, polishing and running-in of gear contact surfaces, and elastic isolation of engine and drive units. One prototype machine in Class 3 complements advanced intake and exhaust silencing with such mechanical modification, and yet reaches a total noise level of only 80 to 82 dBA measured according to the CHP test procedure with performance decreased about 10 percent. Furthermore, experimentation is proceeding on such advanced techniques as the use of nonresonating materials for lightly loaded components, use of quieter plain bearings instead of the common roller or ball variety, increased forced lubrication, more effective decoupling of components from the engine or frame, water cooling (already used on large displacement multicylinder two-cycle machines), drive chain enclosures, shaft drive, and double construction or increased damping of engine and transmission cases. Mechanical levels between 78 and 74 dBA constitute the horizon of industry's engineering predictions incorporating combinations of the above treatments for Class 3 machines. Extensive machine redesign is indicated by several of these treatments; hence, mechanical levels will not be reduced at the source without a great deal of effort.

For the small Class 1 motorcycles, the mechanical noise levels from four-cycle engines may be significantly more difficult to reduce than two-cycle mechanical noise. This is suggested by Figure 2, which shows 1973 model two-cycle Class 1 machines to be quieter than four-cycle models. Such a situation might be expected, since two-cycle engines do not contain the kind of valve systems which are responsible for much four-cycle engine mechanical clatter. Thus, reduction of mechanical noise from four-cycle engines smaller than 100 cc may require a more extensive and complicated application of noise reduction techniques than necessary for two-cycle counterparts.

A standard approach to reduction of mechanical and engine noise in transportation vehicles involves acoustic encapsulation or shielding of the noise sources. Barriers and engine compartments provide a considerably less costly and complex solution to the problem than extensive mechanical rework, and could conceivably provide a noise reduction of up to 5 dB, as with larger automotive vehicles. Effective encapsulation is difficult to provide for air cooled engines due to necessary provisions for the cooling airflow (inlet and outlet apertures, ducting, blower). When the weight, spatial, and extreme cooling requirements of a motorcycle are considered, applicability of encapsulation appears more uncertain. Motorcycle manufacturers claim that encapsulation or shielding of mechanical noises is completely inapplicable to their products due principally to cooling requirements, but less importantly because of other standard performance reasons, such as increased weight. Still, certain large size English models with semi-enclosed engines have infrequently appeared as recently as the mid-1960s with no apparent mechanical difficulties. Also, the Italian style motor scooters and well known "Honda 50" type machines have been quite popular in recent years and acceptably reliable with partially enclosed engines. Thus, although no noise data has become available for these examples, shielding of mechanical noises to some extent may be feasible for today's vehicles. It may be noted that the manufacturers of the above-mentioned English machines were since forced to retire from the motorcycle business. Although engine enclosures were not likely to blame, they do represent an old style design philosophy quite different from the current U.S. fashion. The conceivable changes in appearance, weight, bulk, simplicity, power, and ease of maintenance could perhaps create serious marketing difficulties. Alternatively, the streamlined fairings now popular in Europe may significantly shield mechanical noise while improving high speed performance (See Aerodynamic Section, Page 49). The lack of industry experimentation leaves the actual aesthetic and noise reduction potential undetermined.

Exceptions to the rule of high engine noise levels do exist. One manufacturer, whose product has been characterized for many years by smooth running and high reliability, deals very effectively with primary noise sources through an elaborate enclosed intake system and large mufflers. Also, an impressive lack of engine mechanical noise is evident, due largely to use of solid bearings and small clearances. The enclosed shaft drive, whose ring and pinion gears are preassembly run in, eliminates final drive noise. Vibration is greatly limited by the "opposed" engine design which almost completely balances primary reciprocating engine forces. In this way, a reasonably performing large displacement 1973 production motorcycle attains noise levels below 80 dBA. However, the machines have only recently begun to escape long standing characteristics of low performance and slow response. While maintaining low noise levels and high reliability, the rated power is from 5 to 39 percent below, and retail price from 5 to 75 percent above values from machines of equal engine displacement exhibiting higher noise levels. Thus, penalties have been incurred in this classic example of smooth machinery and noise control.

The in-use and prospective techniques for reducing mechanical noise levels may be summarized as follows:

13. Stiffening of cooling fins with rubber or cast-in webs, and stiffening of engine/drive cases with cast-in webs
14. Staggered shape casting of cooling fins
15. Finely finished and run-in gears; use of helical primary drive gears
16. Simple engine/drive unit vibration isolation
17. Enclosed final drive chain
18. Heavy final drive chain case
19. Double construction and damping of engine/drive cases
20. Advanced engine/drive isolation system
21. Use of plain bearings
22. Increased lubricant flow and pressure

23. Encapsulation of engine/drive units
24. Liquid cooling
25. Shaft final drive
26. Decreased working clearances.

The costs of applying these techniques together with the corresponding approximate reductions in engine associated noise are shown generally in Figure 11, and specifically in Table 6 for reduction to the three selected noise levels.

Aerodynamic and Tires

Typical noise levels produced by the combination of aerodynamic sources and tire/roadway interactions are in the range of 60 to 65 dBA at 50 feet from the motorcycle. Although these levels are negligible contributions to present day total motorcycle noise levels, existing future requirements for 75 and 70 dBA motorcycles may require serious investigation of these sources. Turbulence caused by the motion of machine parts through the air may be reduced with detail part changes. Solid or thick spoked cast alloy wheels instead of wire spoke wheels are appearing on custom and racing machines, and may provide substantially less air disturbance. It has also been suggested that the now common disc brake produces more air flow turbulence, and thus more flow noise, than the conventional drum type. The maze of cables, levers, and wires undoubtedly contributes to aerodynamic noise which streamlining or routing through vehicle components might reduce. The question of overall vehicle streamlining to eliminate the various protuberances has long been posed by various safety advocates, and reduced windage noise could be a result. Fairings, fiberglass streamlinings covering the entire front of the machine, are commonly found in Europe and may represent a first step. Their aerodynamic qualities are known to yield 5 to 10 percent increases in maximum speed. Little research has been conducted regarding motorcycle tire noise due to the low magnitude of the problem, common investigations being oriented toward higher traction and longer wear for the powerful machines appearing on the market. Tubeless tires exist for road racing purposes, but it is unknown whether these or various highway tread patterns have differing noise characteristics.

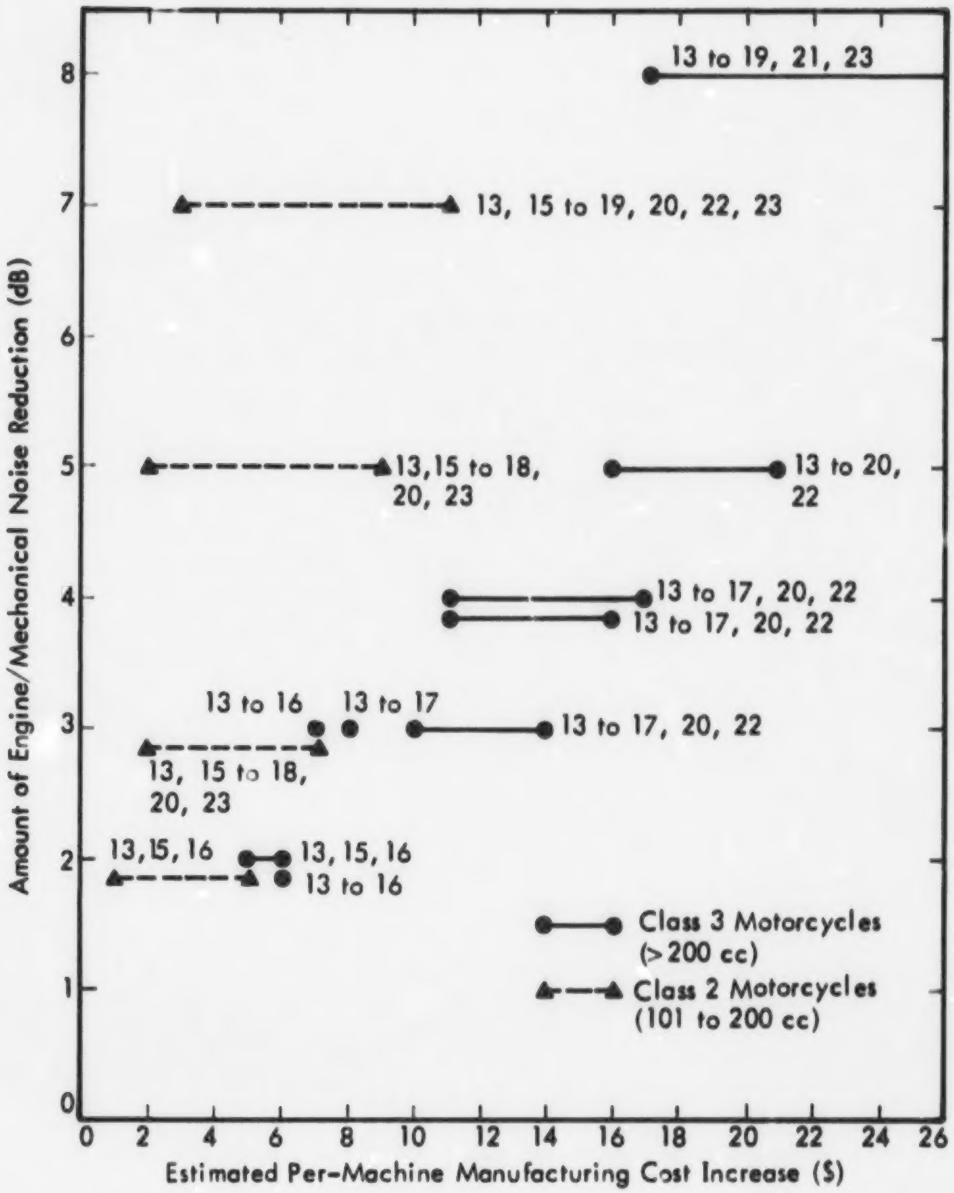


Figure 11. Estimated Costs for Reduction of Motorcycle Engine/Mechanical Noise

- Insufficient noise level/cost data exist for inclusion of Class 1 (0 to 100 cc) machines.
- These estimated cost ranges are for typical example modifications to various machines of average 1973 noise characteristics as summarized in Tables 7, 8 and 9.
- Numbers represent noise control techniques as listed in text.

Table 6

Required Engine/Mechanical Noise Modifications and Associated Costs to Achieve the Selected Noise Levels

Selected Noise Level	Machine Class	Average Mechanical Noise Contribution (CHP Test Method)[1]	Maximum Modifications Required[2]	Per-Machine Estimated Manufacturing Cost Increase[3]
Typical 1973	Class 1 Class 2 Class 3	—[4] ~77 dBA 78 to 80 dBA	—[5] —[5] —[5]	—[5] —[5] —[5]
Level 1	Class 1 Class 2 Class 3	—[4] ~75 dBA 75 to 78 dBA	—[4] 13, 15, 16 13, 15, 16, 17	$0 to $2[6] $1 to $5 $5 to $8
Level 3	Class 1 Class 2 Class 3	—[4] ~74 dBA 74 to 78 dBA	—[4] 13,15,16,17,20,23 13 to 17, 20, 22	$0 to $4[6] $2 to $7 $6 to $16
Level 2	Class 1 Class 2 Class 3	—[4] ~72 dBA 74 to 75 dBA	—[4] 13,15,16,17,20,23 13 to 19, 21, 23	$1 to $6[6] $2 to $9 $7 to $21

[1] These mechanical noise level ranges are those required to achieve the Selected Levels with typical 1973 machines when combined with the necessary exhaust and intake subsource noise levels developed elsewhere in this section.

[2] Numbers represent noise control techniques listed in text.

[3] All costs are increases from mid-1973 manufacturing costs including direct and indirect labor and materials, and engineering and development.

[4] Insufficient data exist to accurately determine average subsource noise levels for machines smaller than 100 cc.

[5] Not applicable.

[6] Costs for under 100 cc machines are estimated from cost projections for total noise reduction provided by industry.

Advanced Concepts for Noise Reduction

The noise control techniques included above are conventional methods applicable to most types of machinery and approachable through standard engineering procedures. For many of them, much experimentation and development remains to establish effects or feasibility, but they do not involve radical departure from existing configurations. Exceptions to such modifications include repowering with new engine types. Electrically powered two-wheeled vehicles are now being produced in limited numbers in the United States, but most performance characteristics are below average for current model gasoline motorcycles of comparable price. Production rotary Wankel powered models are expected to be available in late 1974 with CHP procedure noise levels approaching 80 dBA. However, performance comparability to reciprocating engine machines and in-service reliability have not yet been established. Reciprocating steam and gas turbine motorcycles have been constructed for various experimental purposes, and although they might be workable with development, none show exceptional promise for noise control in the near future.

Achievement of the Selected Noise Levels Through Application of Noise Reduction Techniques

The previous discussion of techniques to reduce noise emitted from various individual sources on the motorcycle has focused on reducing exhaust, intake, and mechanical noise. The noise control cost information developed for these subsources can be combined to determine the total costs of noise reduction to the three selected noise levels. These costs, together with the required modifications and individual subsource levels are shown in Tables 7 and 8 for typical 1973 motorcycles.

For motorcycles in Class 3, cases in which total vehicle noise is dominated by exhaust, intake, and mechanical sources, and in which all subsources are about equal, are analyzed. The subsource noise levels used are average levels for 1973 model machines, and the modifications accomplished to reduce these levels, indicated in the vertical columns of Table 7 by estimated costs, represent typical approaches to total

Table 7

Estimated Per-Machine Manufacturing Cost Increases for Noise Reduction of Typical Full-Size Motorcycles >200 cc.

	Selected Achieved Total Noise Level	Level #1				Level #3			Level #2			76 dBA
		82 dBA	82 dBA	82 dBA	82 dBA	80 dBA	80 dBA	80 dBA	78 dBA	78 dBA	78 dBA	
	Vehicle Modified*	E(50%)	I(40%)	M(5%)	A**(5%)	E(50%)	I(40%)	M(5%)	E(50%)	I(40%)	M(5%)	A**(5%)
– Subsource Modifications –	EXHAUST	82→77 dBA	77→75 dBA	79→77 dBA	80→75 dBA	82→77 dBA	77→74 dBA	79→74 dBA	82→72 dBA	77→72 dBA	79→72 dBA	80→72 dBA
	Increase Volume 50 to 100%	$3 to $12	$3 to $8	$3 to $8	$3 to $12	$3 to $12	$3 to $10	$3 to $12	$3 to $12	$3 to $10	$3 to $12	$3 to $12
	Modify Baffles	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	-
	Elastic Components	$1 to $2	-	-	-	$1 to $2	-	$2	$2	-	$2	$2
	Double Walls	-	-	-	-	-	-	-	$4 to $6	$4 to $6	$4 to $6	$4 to $6
	Increase Baffling	-	-	-	-	-	-	-	$2 to $3	-	-	-
	INTAKE	77 dBA	82→78 dBA	79→78 dBA	80→79 dBA	77→75 dBA	82→78 dBA	79→74 dBA	77→72 dBA	82→72 dBA	79→72 dBA	80→72 dBA
	Minimize Inlet X-Section	-	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1
	Plenum Chamber	-	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2
	Internal Baffles	-	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2
	Inlet Shielding	-	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1
	Increase Enclosure Volume 50 to 100%	-	$1 to $3	-	-	$1 to $3	$1 to $3	$1 to $3	$1 to $3	$1 to $3	$1 to $3	$1 to $3
	Double Walls	-	-	-	-	-	-	-	-	$2 to $4	$2 to $4	$2 to $4
	Apply Absorptive Linings	-	-	-	-	-	-	$1 to $2	$1 to $2	$1 to $2	$1 to $2	$1 to $2
	MECHANICAL	78 dBA	78 dBA	80→78 dBA	78→75 dBA	78→75 dBA	78→74 dBA	80→78 dBA	78→75 dBA	78→74 dBA	80→75 dBA	78→70 dBA
	Stiffening Fin and Case Webs	-	-	$1 to $2	$1	$1	$1 to $2	$1	$1	$1 to $2	$1 to $2	$2
	Change Fin Shape	-	-	-	$1	$1	$2	$1	$2	$2	$2	$2
	Finish and Run-In Helical Gears	-	-	$2	$2	$2	$2	$2	$2	$2	$2	$2
	Simple **Isolation**	-	-	$2	$2	$2	$2	$2	$2	$2	$2	$2
	Enclose Chain	-	-	-	$2	$2	$2	-	-	$2	$2	$1
	Heavy Chain Case	-	-	-	-	-	-	-	-	-	$1	$4
	Double Cases	-	-	-	-	-	-	-	-	-	$4	$1 to $3
	Improve **Isolation**	-	-	-	-	$1 to $3	$1 to $3	-	-	$1 to $3	$1 to $3	-
	Plain Bearings	-	-	-	-	-	-	-	-	-	-	$1 to $3
	Increase Lubrication	-	-	-	-	$1 to $3	$1 to $3	-	-	$1 to $3	$1 to $3	-
	Encapsulation	-	-	-	-	-	-	-	-	-	-	$2 to $10
	Liquid Cooling	-	-	-	-	-	-	-	-	-	-	-
	Shaft Drive	-	-	-	-	-	-	-	-	-	-	-
	Decrease Clearances	-	-	-	-	-	-	-	-	-	-	-
	Total Manufacturing Cost Increase	$4 to $15	$9 to $18	$13 to $21	$16 to $27	$20 to $38	$20 to $36	$18 to $32	$26 to $45	$28 to $48	$34 to $57	$34 to $64

*"Vehicle Modified" indicates typical vehicle with dominant exhaust (E), intake (I), mechanical (M), or even (A) noise sources followed by percent of new vehicles in each category.

**Interpretation of specific manufacturer data.

See Table 9 for noise description of "Vehicle Modified," time required, and additional information.

Table 8

Estimated Per-Machine Manufacturing Cost Increases for Noise Reduction of Typical Small Motorcycles (Motor-Driven Cycles) <200 cc

	Selected Achieved Total Noise Level	Level #1		Level #3		Level #2		74 dBA
		79 dBA	81 dBA	76 dBA	79 dBA	70 dBA	76 dBA	
	Vehicle Size Modified	0 to 100 cc	100 to 200cc*	0 to 100 cc	100 to 200 cc	0 to 100 cc	100 to 200 cc	100 to 200 cc*
– Subsource Modifications –	EXHAUST		78→75 dBA		78→74 dBA		78→70 dBA	78→69 dBA
	Increase Volume 50 to 100%, Modify Baffles	-	$5 to $8	-	$5 to $8	-	$5 to $8	$5 to $8
	Extra Baffles, Elastic Components	-	-	-	$1 to $4	-	$1 to $4	$1 to $4
	Double Walls	-	-	-	-	-	$2 to $6	$2 to $6
	Appropriate Combination	$0 to $2	-	$0 to $3	-	$1 to $5	-	-
	INTAKE		80→78 dBA		80→74 dBA		80→72 dBA	80→70 dBA
	Minimize Inlet X-Section, Interior Baffles, Plenum, Shielding	-	$3	-	$3	-	$3	$3
	Increase Inlet Enclosure Volume 50 to 100%, Apply Absorptive Linings	-	-	-	$2	-	$2 to $4	$2 to $4
	Double Walled Enclosure	-	-	-	-	-	-	$3 to $6
	Appropriate Combination	$0 to $2	-	$0 to $3	-	$1 to $6	-	-
	MECHANICAL		77→75 dBA		77→74 dBA		77→72 dBA	77→70 dBA
	Fin and Case Stiffening Webs, Finish and Run-In Helical Gears, Engine Isolation	-	$1 to $5	-	$1 to $5	-	$1 to $5	$1 to $5
	Enclose Chain, Improve Isolation, Encapsulation	-	-	-	$1 to $2	-	$1 to $4	$1 to $2
	Double Construction Cases, Increase Lubrication	-	-	-	-	-	-	$1 to $4
	Appropriate Combination	$0 to $2	-	$0 to $4	-	$1 to $6	-	-
	Total Manufacturing Cost Increase	$0 to $6	$9 to $16	$0 to $10	$13 to $24	$3 to $17	$15 to $34	$19 to $42

*Based on interpretation of specific manufacturer data.

See Table 9 for noise description of "Vehicle Size Modified," time required, and additional information.

Table 9

Information Explaining Tables 7 and 8

- Tables 7 and 8 itemize the estimated increases in the "cost of goods manufactured" – including engineering costs – required per unit for application of various noise reduction techniques to motorcycles with specific typical 1973 model noise characteristics in order to achieve selected reduced noise levels. The cost ranges developed represent all normal production machines in each model line capable of meeting the selected levels with the modifications indicated.
- These estimated cost increases are for achievement of the Selected Noise Levels by October 1975 and, therefore, essentially represent the differences between the 1973 model and 1976 model manufacturing costs which would be anticipated due to modifications for noise reduction only.
- Total noise levels are those which would be measured by the California Highway Patrol motorcycle measurement procedure (see Appendix B).
- Noise Levels given for exhaust, intake, and mechanical subsources are the approximate contributed levels from these subsources to the total level measured during the California Highway Patrol acceleration noise test.
- The reduction in the noise level contributions of the various noise subsources (which are accomplished by the costed modificiations) are shown in the horizontal rows labeled Exhaust, Intake, and Mechanical.
- The cost ranges given include machines powered by both two-cycle and four-cycle engines.
- Noise characteristics of the "typical 1973 vehicles" modified in Tables 7 and 8 are:

Motorcycles >200cc

Noise Character	Total Noise Level	Exhaust Contribution	Intake Contribution	Mechanical Contribution
Exhaust Dominated	84 dBA	82 dBA	77 dBA	78 dBA
Intake Dominated	84 dBA	77 dBA	82 dBA	78 dBA
Mechanical Dominated	84 dBA	79 dBA	79 dBA	80 dBA
All Sources ~ =	84 dBA	80 dBA	80 dBA	78 dBA

Motor-Driven Cycles <200cc

Engine Size Range	Total Noise Level	Exhaust Contribution	Intake Contribution	Mechanical Contribution
100 - 200cc	83 dBA	78 dBA	80 dBA	77 dBA
<100cc	~80 dBA	Insufficient Detailed Data Available		

noise reduction. Values for typical 1973 subsource levels are given in Table 9. At the bottom of each column in Table 7, the total estimated increase in manufacturing cost is given for the vehicle described in that column to achieve the selected noise level. The specific reductions of subsource levels are shown in the appropriately labeled horizontal row.

This information for machines in Classes 1 and 2 is shown in Table 8, which is similar to Table 7. Because there is less available data for small machines, costs are given for groups of modifications rather than individual cases. For Class 1 motor-driven cycles, little information is available on the effectiveness of subsource modification and so subsource noise reduction costs have been extracted from manufacturers' estimates of the total percentage retail cost which will be required to attain the selected noise levels.

A summary of the developed manufacturing cost increases for achieving the selected noise levels is given in Table 10 and Figures 12 and 13. This information includes average costs, cost ranges as developed for the specific models of Tables 7 and 8, and the range of general industry cost estimates. Specific estimates are shown to fit well within the general manufacturer predictions in Figures 12 and 13.

Table 10 and Figures 12 and 13 also include costs which have been incurred by manufacturers in reducing the noise levels of their machines from 92 dBA – the regulation in California prior to 1970 – down to 84 and 86 dBA, the existing California regulations for motor-driven cycles and full size motorcycles respectively. The new costs developed in Tables 7 and 8 are substantially higher than the costs for past noise reductions because, as noise levels become lower, new techniques have to be developed and applied to an increasing number of subsources. It must be emphasized that the cost figures have been determined for average motorcycle noise characteristics using little precise information on specific modifications. Thus, they serve only as a guide to increased manufacturing costs, due to noise reduction alone, and may vary appreciably for individual models with specific problem subsources.

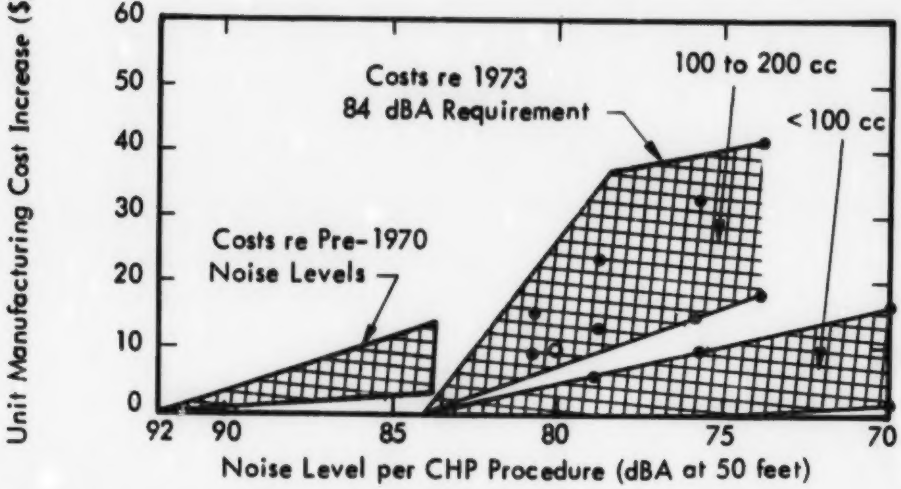


Figure 12. Estimated Noise Reduction Costs for Motor-Driven Cycles <200 cc

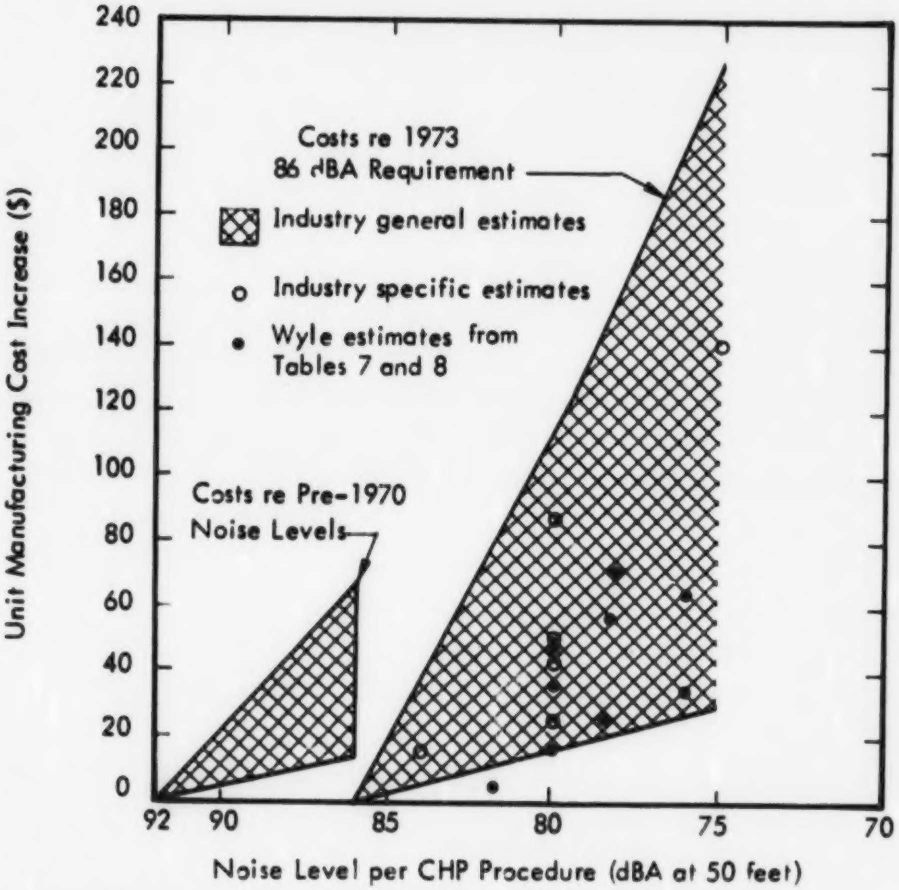


Figure 13. Estimated Noise Reduction Costs for Motorcycles > 200 cc

Table 10

Estimated General New Motorcycle Noise Reduction Costs

Cost Characteristic		1973 Calif. Requirements[1]	Selected Noise Levels[6]		
			Level #1[2]	Level #2[2]	Level #3[2]
Manufacturing Cost Increase Class 1	Average[3]	-	$3	$10	$5
	Specific Range[4]	-	$0 to $6	$3 to $17	$0 to $10
	General Range[5]	1 to 3% $1.50 to $10	$4 to $25	"Large"	$20 to $40
Manufacturing Cost Increase Class 2	Average	-	$13	$24	$19
	Specific Range	-	$9 to $16	$15 to $32	$13 to $24
	General Range	1 to 2.5% $3 to $15	$8 to $20	$18 to $40	$10 to $35
Manufacturing Cost Increase Class 3	Average	-	$13	$37	$28
	Specific Range	-	$4 to $27	$26 to $57	$20 to $38
	General Range	1% to 5% $12 to $68	$10 to $90	$20 to $150	$15 to $110
Loss of Maximum Performance[7]		1% to 5%[8]	-[9]	-[9]	5% to 20%[8]
Fuel Consumption Increase		-[9]	-[9]	-[9]	≤10%[10]

[1] Costs to achieve this level are for the reductions from typical noise levels which existed under the pre-1970 92 dBA California requirement.

[2] Costs to achieve this level are for reductions from typical 1973 noise levels, and include all normal production machines in the model lines which are capable of achieving the selected noise levels.

[3] Average values have been determined from specific examples of Tables 7 and 8 based on percentage of 1973 models with various dominant noise sources.

[4] Specific ranges are the extremes from the specific examples of Tables 7 and 8.

[5] General ranges are manufacturer estimates based on general percent of retail cost or production cost.

[6] Selected noise levels, as measured per California Highway Patrol motorcycle noise measurement procedures, are given in Table 3.

[7] Includes maximum speed, acceleration, cornering speed, etc.

[8] Range of general industry estimates for production machines.

[9] Insufficient data.

[10] Estimate from one major manufacturer.

7. CONCLUSIONS

This study has shown that, although significant reductions in noise from production motorcycles sold in the U.S. have been effected since 1969, further substantial reductions are possible. Treatment principally of intake and exhaust noise has brought large motorcycles within the 1973 California requirement of 86 dBA as measured with the California Highway Patrol procedure, and has been responsible for certain performance decreases and production cost increases of up to 5 percent of preregulation levels. All small machines have been brought into compliance with their lower current regulation of 84 dBA. The principal manufacturers are now working hard toward meeting the difficult 1975 California requirement of 80 dBA with large machines through addition of mechanical noise treatments and further improvements in intake and exhaust silencing. Although some models have already achieved 80 dBA, the main body of available models will suffer further performance and cost changes to meet this level.

In the opinion of Wyle Research, based on the current available data developed during this project, it is within industry capability to reduce the noise levels of approximately half of the field of motorcycles over 200 cc displacement (herein defined as Class 3) to 80 dBA as measured by the CHP standard by October of 1975. This will involve substantial manufacturer development effort and will necessitate production cost increases averaging $28 per machine. Performance could further diminish more than 5 percent, and general industry predictions of fuel consumption increases range as high as 10 percent. The 80 dBA level is within reach for nearly all of the under 200 cc machines by the date of interest. For machines with engine displacements between 100 and 200 cc (Class 2), about three-quarters of the vehicles available in October 1975 could be produced with noise levels at or below 79 dBA for an average per-machine manufacturing cost increase of $19. It is finally estimated that the industry is capable of manufacturing about 75 percent of the under 100 cc machines (Class 1) available in October 1975 with noise levels of 76 dBA or less, with per-machine manufacturing cost increases averaging $5 over 1973 manufacturing costs.

Methods for achieving noise levels below 80 dBA for large motorcycles and 76 dBA for small machines have not been widely developed. The following aspects of noise reduction will require extensive research before widespread lower levels can be expected.

- Mechanical Noise Shielding – The use of barrier or encapsulation techniques to attenuate engine and drive system mechanical noise in its path as an alternative to involved mechanical redesign. Related problems such as engine cooling effects should be addressed. The noise masking effects of existing motorcycle fairings should be determined.
- Use Cycle – Although most of the industry appears content with existing maximum acceleration noise test standards, typical use cycle data would provide information allowing correlation of current noise measurement procedures to real traffic noise levels or development of a new procedure directly related to in-use noise.
- New Power Sources – Further investigation into applicability of unconventional engine types, particularly rotary combustion, should be undertaken to help determine future noise reduction potential.
- Minor Sources – Specific investigation into the presently less important noise subsources: windage, tires, final drive chain, component vibration, etc., should be undertaken to (1) provide data useful in further noise reduction, and (2) define lower bounds for obtainable motorcycle noise reduction.

REFERENCES

1. "Cost Effectiveness Study of Major Sources of Noise, Phase I – Ranking of Major Noise Sources," Wyle Research, for U.S. Environmental Protection Agency, April 20, 1973.
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3. "Motorcycle Noise Test Procedure Evaluation," California Highway Patrol, January 1971.
4. Wyle Research (unpublished analysis), September 1973.
5. Wyle Research (unpublished data), 1971.
6. "Transportation Noise and Noise from Equipment Powered by Internal Combustion Engines," Wyle Laboratories, for Environmental Protection Agency, Report No. NTID 300.13, p 171, December 31, 1971.
7. "CHP Data on 1970 Model Motorcycles," cited in "Hearings Before the Subcommittee on Public Health and Environment of the Committee on Interstate and Foreign Commerce," House of Representatives Serial No. 92-30, June 16-24, 1971.
8. Manufacturers' Noise Level Data Submitted to Wyle Research.
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10. "Sound Pressure Levels Observed During Motorcycle Tests: Street Vehicles, 1973 Stock Model," Bolt Beranek and Newman, Inc., for Motorcycle Industry Council, December 12, 1972.
11. Harrison, R., "The Effectiveness of Motorcycle Helmets as Hearing Protectors," USDA Forest Service Equipment Development Center, San Dimas, California, September 1973.
12. Howell, A.R., "A Study of Wind Induced Noise in the Human Ear," The Industrial Research Institute of the University of Windsor, IRI Project 6-28, for Outboard Marine Corporation, July 1973.
13. Irving, P.E., Motorcycle Engineering, Floyd Clymer Publications.
14. Memorandum from Dr. Ben Sharp, Wyle Research, to Mr. Hugh Kaufman, U.S. Environmental Protection Agency, July 19, 1973.

APPENDIX A

CONTACTS

Motorcycle Manufacturer/Distributors Providing Quantitative Data

American Honda Motor Company, Incorporated
Gardena, California

Butler & Smith Corporation
Norwood, New Jersey
(Distributor: BMW Motorcycles)

The Birmingham Small Arms Company Incorporated
Duarte, California
(Distributor: Triumph, BSA, Rickman Motorcycles)

AMF/Harley-Davidson Motor Company, Incorporated
Milwaukee, Wisconsin

Kawasaki Motors Corporation, U.S.A.
Santa Ana, California

Pacific Basin Trading Company
Athena, Oregon
(Distributor: Hodaka Motorcycles)

U.S. Suzuki Motor Corporation
Santa Fe Springs, California

Yamaha International Corporation
Buena Park, California

Accessory Manufacturers Providing Quantitative Data

Manufacturer	Products
Bassani Manufacturing Anaheim, California	Bassani competition exhausts, silencers
Discojet Corporation Davis, California	Xdusor mufflers
Hooker Headers Ontario, California	Hooker mufflers, competition silencers
J&R Manufacturing Company Bell Gardens, California	J&R spark arrestors, silencers
Murphy Muffler Long Beach, California	Strato-Flex mufflers
Skyway Cycle Products San Fernando, California	Skyway silencers and spark arrestors
Torque Engineering Company Northridge, California	Silencers, spark arrestors, competition exhausts

Other Information Sources

American Motorcycle Association
Westerville, Ohio

City of Chicago
Department of Environmental Control
Chicago, Illinois

CYCLE Magazine
New York, New York

DIRT BIKE Magazine
Encino, California

Motorcycle Industry Council
Washington, D.C.

United States Department of Agriculture
Forest Service Equipment Development Center
San Dimas, California

APPENDIX B

MEASUREMENT STANDARDS

CALIFORNIA HIGHWAY PATROL NOISE MEASUREMENT PROCEDURE
EDITED FOR NEW VEHICLES

ORDER ADOPTING, AMENDING, OR REPEALING REGULATIONS OF THE DEPARTMENT OF THE CALIFORNIA HIGHWAY PATROL

After proceedings had in accordance with the provisions of the Administrative Procedure Act (Gov. Code, Title 2, Div. 3, Part 1, Chapter 4.5) and pursuant to the authority vested by Section 2402 of the Vehicle Code, and to implement, interpret, or make specific Sections 23130 and 27160 of the Vehicle Code, the Department of the California Highway Patrol hereby adopts, amends, or repeals regulations in Chapter 2, Title 13, California Administrative Code, as follows:

(1) Amends Article 10, Subchapter 4 to read:

Article 10. Vehicle Noise Measurement

1040. Scope of Regulations. This article contains procedures implementing Section 23130 of the Vehicle Code which applies to the measurement of noise from motor vehicles and combinations of vehicles subject to registration when operated on a highway, and Section 27160 of the Vehicle Code which applies to the measurement of noise from new motor vehicles offered for sale.

1041. Definitions. The following definitions shall apply wherever the terms are used in this article:

(a) First Gear. The "first gear" is the highest numerical gear ratio of the transmission which is commonly referred to as low gear.

(b) Maximum RPM. The "maximum rpm" is the maximum governed engine speed, or if ungoverned, the rpm at maximum engine horsepower as determined by the engine manufacturer in accordance with the procedures in SAE J245, April 1971.

(c) Vehicle Reference Point. The "vehicle reference point" is the location on the vehicle used to determine when the vehicle is at any of the points on the vehicle path. The vehicle reference point shall be the front of the vehicle unless such position is more than 16 ft from the exhaust outlet, in which case both the front of the vehicle and the exhaust outlet shall be used as reference points.

1042. Personnel. Persons selected to conduct noise measurement testing or to measure noise level of vehicles operated on a highway shall have been trained and qualified in the techniques of sound measurement and the operation of sound measuring instruments.

1043. Instrumentation. Equipment used in making vehicle noise measurements shall be selected by technically trained personnel and shall meet the following requirements:

(a) Sound Level Meter. The sound level meter shall meet the requirements of ANSI Standard S1.4-1971 for Types 1, 2, or S2A.

(b) Sound Level Calibrator. The sound level calibrator shall calibrate the entire sound level meter with an acoustic calibrator of the coupler-type.

(c) Tachometer. A calibrated engine speed tachometer shall be used to determine when maximum rated rpm is attained in conducting the tests specified in Section 1046 of this code.

(d) Anemometer. An anemometer shall be used to measure the wind speed at the test site when conducting tests specified in Section 1046 of this code.

1044. Noise Measurement Sites. Noise measurement sites shall be selected to meet location, ground condition, and roadway surface requirements in the following subsections (a) and (b):

(a) Measurement Sites for Vehicles on the Highway.

(b) Measurement Sites for New Motor Vehicles. Sites for measuring noise from new motor vehicles to determine compliance with Section 27160 of the Vehicle Code shall meet the following conditions:

(1) Location. The location shall be a flat open space free of large vertical sound-reflecting surfaces such as signboards, buildings, hillsides, or trees within 100 ft of the microphone and within 100 ft of the centerline of the path of the vehicle from the point where the throttle is opened to the point where the throttle is closed.

(2) Ground Condition. The ground surface between the microphone and the path of the vehicle shall be asphalt or concrete free of powdery snow, loose soil, or ashes.

(3) Roadway Surface. The surface over which the vehicle travels shall be dry and relatively smooth concrete or asphalt pavement free of extraneous material.

1045. Microphone and Personnel Positions. The microphone for the sound level meter and the personnel involved in all types of vehicle noise measurements shall be positioned as follows:

(a) Microphone Location. The microphone shall be located 50 ± 1 ft from the centerline of the lane of travel of the vehicle at a height of 4 ± 1/2 ft above the plane of the roadway surface.

(b) Microphone Orientation. The microphone shall be oriented in relation to the source of the sound in accordance with the instrument manufacturer's instructions. Where the instruction manual is vague or does not include adequate information, a specific recommendation shall be obtained from the manufacturer.

(c) Technician Location. The technician making direct readings of the meter shall be positioned in relation to the microphone in accordance with the instrument manufacturer's instructions. Where the instruction manual is vague or does not include adequate information, a specific recommendation shall be obtained from the manufacturer.

(d) Bystander Location. During noise measurements, bystanders shall remain at least 50 ft from the microphone and the vehicle being measured, except for a witness or trainee, who may be positioned beyond the technician on a line with the technician and the microphone.

1046. Operation of New Motor Vehicles. New motor vehicles tested to determine compliance with Section 27160 of the Vehicle Code shall be operated in conjunction with any auxiliary equipment that would be in use while the vehicle is operated on the highway, including but not limited to cement mixers, refrigerator units, and garbage compactors.

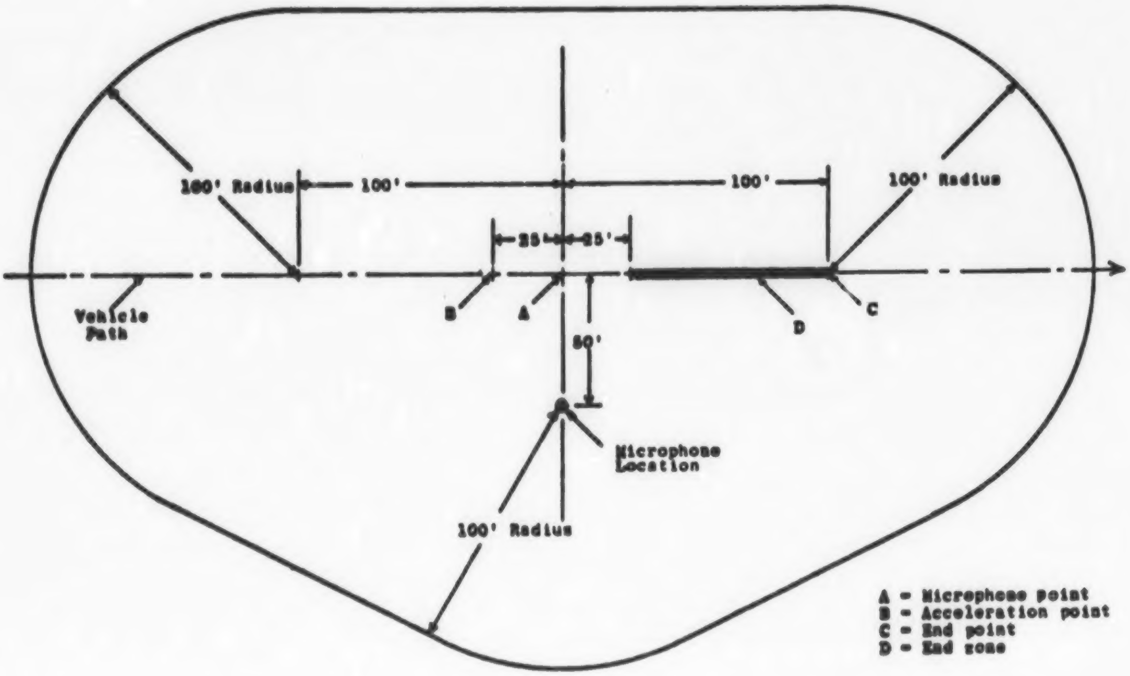
(a) Heavy Trucks, Truck Tractors, and Buses.

(b) Light Trucks, Truck Tractors, Buses, and Passenger Cars.

(c) Motorcycles. The test procedure for motorcycles shall be as follows:

(1) Test Area Layout. The test area layout for motorcycles shall be the same as specified in subsection (b) (1) and Figure 3 for light trucks, truck tractors, buses, and passenger cars. (See next page.)

(2) Gear Selection. Motorcycles shall be operated in second gear. Vehicles which reach maximum rpm at less than 30 mph or before a point 25 ft beyond the microphone point shall be operated in the next higher gear.


100' Radius
100'
100'
100' Radius
25'
25'
Vehicle Path
B
A
50'
D
C
Microphone Location
100' Radius
A - Microphone point
B - Acceleration point
C - End point
D - End zone

Test Area Layout. The test area shall include a vehicle path of sufficient length for safe acceleration, deceleration, and stopping of the vehicle. The vehicle path (shown with only one directional approach in Figure 3 for purposes of clarification) shall be marked with the following zone and points:

(A) Microphone point - the location on the centerline of the vehicle path that is closest to the microphone.

(B) Acceleration point - a location 25 ft before the microphone point.

(C) End point - a location 100 ft beyond the microphone point.

(D) End zone - the last 75-ft distance between the microphone point and the end point.

Figure 3. Test Area Layout for Light Trucks, Truck Tractors, Buses, Passenger Cars, and Motorcycles

(3) Acceleration. The vehicle shall proceed along the test path at a constant approach speed which corresponds either to an engine speed of 60% of maximum rpm or to 30 mph, whichever is lower. When the vehicle reference point reaches the acceleration point, the throttle shall be fully opened. The throttle shall be held open until the rear of the vehicle is approximately 100 ft beyond the microphone or until the maximum rpm is obtained, at which point the throttle shall be gradually closed. Wheel slip shall be avoided during this test.

(4) Engine Temperature. The engine temperature shall be within normal operating range before each test run.

(d) Deceleration. Tests during deceleration shall be conducted when deceleration noise appears excessive. The vehicle shall approach the end point from the reverse direction at maximum rpm in the same gear selected for the tests during acceleration. At the end point, the throttle shall be closed and the vehicle shall be allowed to decelerate to 1/2 of maximum rpm.

1047. Meter Operation. The sound level meter shall be operated in accordance with the instrument manufacturer's instructions and as follows:

(a) Meter Setting. The A-weighting network and the fast meter response shall be used.

(b) Calibration Check. An external calibration check shall be made before and after each period of use and at intervals not exceeding 2 hr when the instrument is used longer than a 2-hr period.

(c) Meter Reading. The reading recorded shall be the highest sound level obtained as the vehicle passes by, disregarding unrelated peaks due to extraneous ambient noises.

(d) Ambient Sound. Measurements shall be made only when the A-weighted ambient sound level, including wind effects, due to all sources other than the vehicle being measured, is at least 10 dB(A) lower than the sound level of the vehicle.

(e) Wind. Measurements shall be made only when the wind velocity is less than 12 mph.

1048. Vehicle Noise Level. The measured noise level of a vehicle shall be reported as follows:

(a) Vehicles on the Highway.....

(b) New Motor Vehicles. The sound level readings for determining compliance of new motor vehicles with Section 27160 of the Vehicle Code shall be obtained after sufficient preliminary runs to enable the test driver to become familiar with the operation of the vehicle and to stabilize engine operating conditions.

> (1) At least four measurements shall be made from each side of the vehicle. When the exhaust outlet is more than 16 ft from the driver's position, at least two runs in each direction shall be performed with each of the reference points described in Section 1041 (c) of this code.
>
> (2) The A-weighted sound level for each side of the vehicle shall be the average of the two highest readings on that side which are within 2 dB(A) of each other. The noise level reported for the vehicle shall be the sound level of the loudest side.

January 18, 1971

Draft #4

61.A1245.A1430

SOUND LEVELS FOR MOTORCYCLES - SAE J331

SAE Standard

1. INTRODUCTION

This SAE Standard established test procedure, environment, and instrumentation for determining maximum sound levels for all classes of motorcycles.

2. SOUND LEVEL LIMITS

3. INSTRUMENTATION

The following instrumentation shall be used for the measurement required:

3.1 A sound level meter which meets the requirements of International Electroacoustic Commission Publication 179, Precision Sound Level Meters (IEC) and American National Standards 1.4-1961 "General Purpose Sound Level Meters" (ANSI).

3.1.1 As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape recorder and/or a graphic level recorder or indicating meter providing the system meets the requirements of SAE Recommended Practice J184, Qualifying a Sound Data Acquisition System.

3.2 A sound level calibrator (see Section 6.3.4).

3.3 A calibrated engine speed tachometer.

3.4 An anemometer.

4. TEST SITE

4.1 A suitable test site is a flat open space free of large reflecting surfaces, such as parked vehicles, signboards, buildings, or hillsides, located within 100 ft of either the vehicle or the microphone.

4.1.1 The ambient sound level at the test site (including wind effects) due to sources other than the vehicle being measured shall be at least 10 dB(A) lower than the level of the tested vehicle.

4.1.2 The surface of the ground within the measurement area between the vehicle being measured and the microphone shall be dry concrete or asphalt, free from powdery snow, loose soil, or ashes.

4.2 The test area layout shall include a vehicle path that is of relatively smooth, dry concrete or asphalt, free of extraneous materials such as gravel and of sufficient length for safe acceleration, deceleration, and stopping of the vehicle. The following points and zones shall be established on the vehicle path:

4.2.1 The microphone shall be located 50 ft ± 1 ft from the centerline of the vehicle path and 4 ft ± ½ ft above the ground plane. The microphone point is that location on the centerline of the vehicle path which is closest to the microphone.

4.2.2 The end point shall be established on the vehicle path 25 ft from the microphone point.

4.2.3 The end zone is the lat 10 ft of vehicle path prior to the end point.

4.2.4 The acceleration point shall be established so that the vehicle will be in the end zone as near as practical to the end point when the engine speed at maximum rated horsepower is attained.

To establish the acceleration point, approach the end point in low gear from the reverse direction at a constant speed obtained from 2/3 of the engine speed at maximum rated horsepower. At the end point fully open the throttle and accelerate past the microphone point under full acceleration. By trial select the lowest transmission gear that will result in the vehicle traveling the shortest distance from the end point to the place where the engine speed at maximum rated horsepower is reached, but not less than 50 ft. The location on the vehicle path with respect to the operator's position when the engine speed at maximum rated horsepower is attained is the acceleration point.

5. PROCEDURE

5.1 For the test under acceleration, the vehicle shall proceed along the vehicle path at a constant approach speed in the gear selected in paragraph 4.1.4 and at 2/3 of the engine speed at maximum rated horsepower.

When the driver's position is at the acceleration point, the throttle shall be rapidly and fully opened. Full throttle shall continue until the engine speed at maximum rated horsepower is reached, which shall be within the end zone as near as practical to the end point. When the engine speed at maximum rated horsepower is reached, the throttle shall be closed. Wheel slip which affects the maximum sound level shall be avoided and the manufacturer's safe maximum rpm shall not be exceeded.

5.2 For the test under deceleration, approach the end point from the reverse direction at an engine speed of maximum rated horsepower in the gear selected for the acceleration test. At the end point, close the throttle and allow the vehicle to decelerate to an engine speed of at least one-half of the rpm at maximum rated horsepower.

5.3 The engine temperature shall be within the normal operating range prior to each run.

5.4 Measurements.

5.4.1 While making sound level measurements, not more than one person other than the observer reading the meter shall be within 50 ft of the vehicle or microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

5.4.2 The meter shall be set for "fast" response and for the A-weighting network.

5.4.3 The meter shall be observed while the vehicle is accelerating. The applicable reading shall be the highest sound level obtained for the run ignoring unrelated peaks due to extraneous ambient noises.. At least four measurements shall be made for each side of the vehicle. All values shall be recorded. Sufficient preliminary runs to familiarize the driver and to establish the engine operating conditions shall be made before measurements begin.

5.4.4 The sound level for each side of the vehicle should be the average of the two highest readings which are within 2 dB(A) of each other. The sound level reported shall be that of the loudest side of the vehicle.

6. GENERAL COMMENTS

6.1 Technically trained personnel should select equipment and tests should be conducted only by qualified persons trained in the current techniques of sound measurement.

6.2 An additional 2 dB tolerance over the sound level limit is recommended when rechecking a vehicle at a different time and location should be allowed to provide for variations in test site, vehicle operation, temperature gradients, wind velocity gradients, test equipment, and inherent differences in nominally identical vehicles.

6.3 Proper usage of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer should be referred to for both recommended operation of the instrument and precautions to be observed. Specific items to be considered are:

6.3.1 The type of microphone, its directional response characteristics, and its orientation relative to the ground plane and source of noise;

6.3.2 The effects of ambient weather conditions on the performance of all instruments (e.g., temperature, humidity, and barometric pressure);

6.3.3 Proper signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems;

6.3.4 Proper acoustical calibration procedure, to include the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Internal calibration means is acceptable for field use, provided that external calibration is accomplished immediately before or after field use.

6.5 Vehicles used for tests must not be operated in a manner such that the break-in procedure specified by the manufacturer is violated.

7. REFERENCES

Suggested reference material is as follows:

1. ANS S1.1 - 1960 Acoustical Terminology
2. ANS S1.4 - 1961 General Purpose Sound Level Meters
3. ANS S1.2 - 1962 Physical Measurement of Sound
4. I. E. C. Publication 179, Precision Sound Level Meters (available from ANSI).

Applications for copies of these documents should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.

UDC 534

Ref. No.: ISO/R 362 - 1964 (E)

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 362

MEASUREMENT OF NOISE EMITTED BY VEHICLES

1st EDITION
February 1964

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BRIEF HISTORY

The ISO Recommendation R 362, *Measurement of Noise Emitted by Vehicles*, was drawn up by Technical Committee ISO/TC 43, *Acoustics*, the Secretariat of which is held by the British Standards Institution (B.S.I.).

Work on this question by the Technical Committee began in 1958 and led, in 1960, to the adoption of a Draft ISO Recommendation.

This first Draft ISO Recommendation (No. 419) was circulated to all the ISO Member Bodies for enquiry, in November 1960. Taking into account the observations put forward by the Technical Committee ISO/TC 22, *Automobiles*, regarding mechanical specifications, Technical Committee ISO/TC 43 presented a Second Draft ISO Recommendation, which was circulated to all the ISO Member Bodies in May 1962, and which was approved, subject to a few modifications of an editorial nature, by the following Member Bodies:

- Australia
- Austria
- Belgium
- Brazil
- Canada
- Chile
- Czechoslovakia
- Denmark
- Finland
- France
- Germany
- Greece
- Hungary
- India
- Ireland
- Israel
- Netherlands
- New Zealand
- Poland
- Portugal
- Spain
- Sweden
- Switzerland
- United Kingdom
- U.S.A.
- U.S.S.R.
- Yugoslavia

One Member Body opposed the approval of the Draft: Japan.

The second Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in February 1964, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 362 February 1964

MEASUREMENT OF NOISE EMITTED BY VEHICLES

1. SCOPE

This ISO Recommendation describes methods of determining the noise emitted by motor vehicles, these being intended to meet the requirements of simplicity as far as is consistent with reproducibility of results and realism in the operating conditions of the vehicle.

2. GENERAL REQUIREMENTS

2.1 Test conditions

This ISO Recommendation is based primarily on a test with vehicles in motion, the ISO reference test. It is generally recognized to be of primary importance that the measurements should relate to normal town driving conditions, thus including transmission noise etc. Measurements should also relate to vehicle conditions which give the highest noise level consistent with normal driving and which lead to reproducible noise emission. Therefore, an acceleration test at full throttle from a stated running condition is specified.

Recognizing, however, that different practices already exist, specifications of two other methods used are also given in the Appendix. These relate to:

(a) a test with stationary vehicles (see Appendix A1) and

(b) a test with vehicles in motion, under vehicle conditions which (in the case of certain vehicles) are different from those in the ISO reference test (see Appendix A2).

When either of these tests is used, the relation between the results and those obtained by the ISO reference test should be established for typical examples of the model concerned.

2.2 Test site

The test methods prescribed call for an acoustical environment which can only be obtained in an extensive open space. Such conditions can usually be provided

for type-approval measurements of vehicles,

for measurements at the manufacturing stage, and

for measurements at official testing stations.

It is desirable that spot checking of vehicles on the road should be made in a similar acoustical environment. If measurements have to be carried out on the road in an acoustical environment which does not fulfil the requirements stated in this ISO Recommendation, it should be recognized that the results obtained may deviate appreciably from the results obtained using the specified conditions.

2.3 Interpretation of results

The results obtained by the methods specified give an objective measure of the noise emitted under the prescribed conditions of test. Owing, however, to the fact that the subjective appraisal of the annoyance or noisiness of different classes of motor vehicles is not simply related to the indications of a sound level meter, it is recognized that the correct interpretation of results of the measurements in this ISO Recommendation may require different limits to be set for the corresponding annoyance of different classes of vehicles.

3. MEASUREMENT EQUIPMENT

A high quality sound level meter should be used. The weighting network and meter time constant employed should be curve " A " and " fast response " respectively, as specified in Recommendation No. 123 of the International Electrotechnical Commission for Sound Level Meters. A detailed technical description of the instrument used should be supplied.

NOTES

1. The sound level measured using sound level meters having the microphone close to the instrument case may depend on the orientation of the instrument with respect to the sound source, as well as on the position of the observer making the measurement. The instructions given by the manufacturer concerning the orientation of the sound level meter with respect to the sound source and the observer should therefore be carefully followed.
2. If a wind shield is used for the microphone, it should be remembered that this may have an influence on the sensitivity of the sound level meter.
3. To ensure accurate measurements, it is recommended that before each series of measurements the amplification of the sound level meter be checked, using a standard noise source and adjusting as necessary.
4. It is recommended that the sound level meter and the standard noise source be calibrated periodically at a laboratory equipped with the necessary facilities for free-field calibration.

Any peak which is obviously out of character with the general sound level being read should be ignored.

4. ACOUSTICAL ENVIRONMENT

The test site should be such that hemispherical divergence exists to within ± 1 dB.

NOTE.—A suitable test site, which could be considered ideal for the purpose of the measurements, would consist of an open space of some 50 m radius, of which the central 20 m, for example, would consist of concrete, asphalt or similar hard material.

In practice, departure from the so-called " ideal " conditions arises from four main causes:

(*a*) sound absorption by the surface of the ground;

(*b*) reflections from objects, such as buildings, and trees, or from persons;

(*c*) ground which is not level or of uniform slope over a sufficient area;

(*d*) wind.

It is impracticable to specify in detail the effect produced by each of these influences. It is considered important, however, that the surface of the ground within the measurement area be free from powdery snow, long grass, loose soil or ashes.

To minimise the effect of reflections, it is further recommended that the sum of the angles subtended at the position of the test vehicle by surrounding buildings within 50 m radius should not exceed 90° and that there be no substantial obstructions within a radius of 25 m from the vehicle.

Acoustical focussing effects and sites between parallel walls should be avoided.

Wherever possible, the level of ambient noise (including wind noise and—for stationary tests—roller stand and tyre noise) should be such that the reading produced on the meter is at least 10 dB below that produced by the test vehicle. In other cases, the prevailing noise level should be stated in terms of the reading of the meter.

NOTE.—Care should be taken that gusts of wind do not distort the results of the measurements.

The presence of bystanders may have an appreciable influence on the meter reading, if such persons are in the vicinity of the vehicle or the microphone. No person other than the observer reading the meter should therefore remain in the neighbourhood of the vehicle or the microphone.

NOTE.—Suitable conditions exist, if bystanders are at a distance from the vehicle which is at least twice the distance from vehicle to microphone.

5. MEASUREMENTS WITH VEHICLES IN MOTION

5.1 Testing ground

The testing ground should be substantially level, and its surface texture such that it does not cause excessive tyre noise.

5.2 Measuring positions

The distance from the measuring positions to the reference line *CC* (Fig. 1) on the road should be 7.5 m. The path of the centre line of the vehicle should follow as closely as possible the line *CC*.

The microphone should be located 1.2 m above the ground level.

5.3 Number of measurements

At least two measurements should be made on each side of the vehicle as it passes the measuring positions.

NOTE.—It is recommended that preliminary measurements be made for the purpose of adjustment. Such preliminary measurements need not be included in the final result.

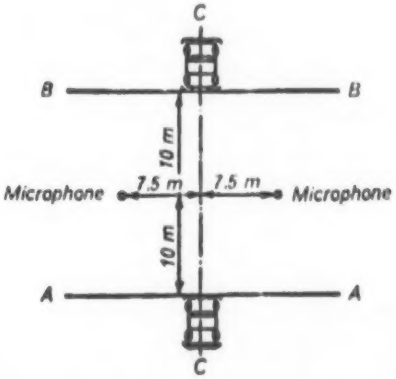


Fig. 1. — Measuring positions for measurement with vehicles in motion

5.4 Test procedure

5.4.1 *General conditions*

The vehicle approaches the line *AA* in the appropriate conditions specified below:

When the front of the vehicle reaches the position, in relation to the microphone, shown as *AA* in Figure 1, the throttle is fully opened as rapidly as practicable and held there until the rear of the vehicle reaches position *BB* in Figure 1, when the throttle is closed as rapidly as possible.

Trailers, including the trailer portion of articulated vehicles, are ignored when considering the crossing of line *BB*.

NOTE.—If the vehicle is specially constructed with equipment (such as concrete mixers, compressors, pumps, etc.), which is used whilst the vehicle is in normal service on the road, this equipment should also be operating during the test.

5.4.2 *Particular conditions*

5.4.2.1 VEHICLE WITH NO GEAR-BOX. The vehicle should approach the line *AA* at a steady speed corresponding

either to an engine speed of three quarters of the speed at which the engine develops its maximum power,

or to three quarters of the maximum engine speed permitted by the governor,

or to 50 km/h,

whichever is the lowest.

5.4.2.2 VEHICLE WITH A MANUALLY OPERATED GEAR-BOX. If the vehicle is fitted with a two-, three-, or four-speed gear box, the second gear should be used. If the vehicle has more than four speeds, the third gear should be used. Auxiliary step-up ratios (" overdrive ") should not be engaged. If the vehicle is fitted with an auxiliary reduction gear box, this should be used with the drive allowing the highest vehicle speed.

The vehicle should approach the line *AA* at a steady speed corresponding

either to an engine speed of three quarters of the speed at which the engine develops its maximum power,

or to three quarters of the engine speed permitted by the governor,

or to 50 km/h,

whichever is the lowest.

5.4.2.3 VEHICLE WITH AN AUTOMATIC GEAR-BOX. The vehicle should approach the line *AA* at a steady speed of 50 km/h or at three quarters of its maximum speed, whichever is the lower. Where alternative forward drive positions are available, that position which results in the highest mean acceleration of the vehicle between lines *AA* and *BB* should be selected.

The selector position which is used only for engine braking, parking or similar slow manœuvres of the vehicle should be excluded.

5.4.2.4 AGRICULTURAL TRACTORS, SELF-PROPELLED AGRICULTURAL MACHINES AND MOTOR CULTIVATORS. The vehicle should approach the line *AA* at a steady speed of three quarters of the maximum speed which can be achieved, using the gear-box ratio which gives the highest road speed.

5.5 Statement of results

All readings taken on the sound level meter should be stated in the report.

The basis of horsepower rating, if appropriate, should be stated in the report.

The state of loading of the vehicle should also be specified in the report.

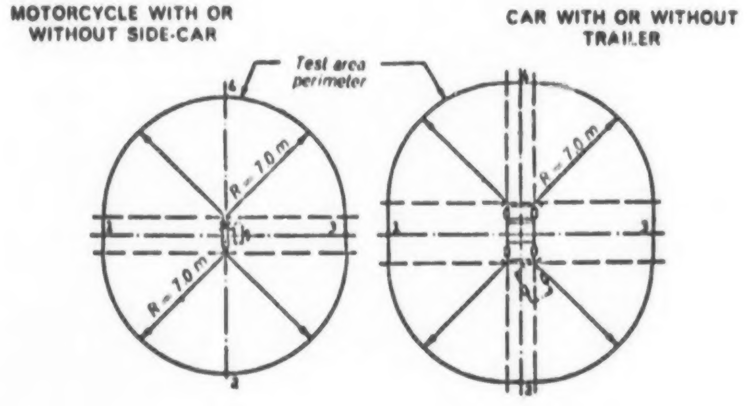
APPENDICES

A1. MEASUREMENTS WITH STATIONARY VEHICLES

A1.1 Measuring positions

Measurements are made in each of the four main directions at a distance of 7.0 m from the nearest surface of the vehicle. The actual positions used for the measurements are shown in Figure 2. If measurements are required in more than the four measuring positions shown in Figure 2, they should be taken from chosen positions on the circles shown — i.e. the circles with radius 7.0 m.

The microphone should be located 1.2 m above the ground level.


MOTORCYCLE WITH OR WITHOUT SIDE-CAR

CAR WITH OR WITHOUT TRAILER

Fig. 2. — Measuring positions for measurement with stationary vehicles

A1.2 Number of measurements

At least two measurements should be made in each measuring position.

A1.3 Vehicle conditions

The engine of the vehicle without a speed governor should be run at three quarters of the number of revolutions per minute at which, according to the manufacturer, it develops its maximum power. The engine speed, expressed in revolutions per minute, is measured by means of an independent instrument, e.g. by the use of free-running rollers and a tachometer. A governed engine should be run at maximum speed.

The engine should be brought to its usual working temperature before measurements are carried out.

A1.4 Statement of results

All the sound level readings observed in each measuring position should be stated in the report.

A2. MEASUREMENTS WITH VEHICLES IN MOTION (MODIFIED METHOD)

A2.1 Testing ground

The testing ground should be substantially level, and its surface texture such that it does not cause excessive tyre noise.

A2.2 Measuring positions

The distance from the measuring positions to the reference line *CC* (Fig. 1) on the road should be 7.5 m. The path of the centre line of the vehicle should follow as closely as possible the line *CC*.

The microphone should be located 1.2 m above the ground level.

A2.3 Number of measurements

At least two measurements should be made on each side of the vehicle as it passes the measuring positions.

NOTE.—It is recommended that preliminary measurements be made for the purpose of adjustment. Such preliminary measurements need not be included in the final result.

A2.4 Test procedure

A2.4.1 *General conditions*

The vehicle approaches the line *AA* in the appropriate conditions specified below:

When the front of the vehicle reaches the position, in relation to the microphone, shown as *AA* in Figure 1, the throttle is fully opened as rapidly as practicable and held there until the rear of the vehicle reaches position *BB* in Figure 1, when the throttle is closed as rapidly as possible.

Trailers, including the trailer portion of articulated vehicles, are ignored when considering the crossing of line *BB*.

NOTE.—If the vehicle is specially constructed with equipment (such as concrete mixers, compressors, pumps, etc.), which is used whilst the vehicle is in normal service on the road, this equipment should also be operating during the test.

A2.4.2 *Particular conditions*

Vehicles should be driven in such a manner as to comply with either of the following conditions.

A2.4.2.1 VEHICLE WITH A MANUALLY OPERATED GEAR BOX, WITH OR WITHOUT AUTOMATIC CLUTCH. The vehicle should approach the line *AA* (Fig. 1) at a steady speed corresponding to three quarters of the revolutions per minute at which the engine (according to the manufacturer) develops its maximum power. The gear ratio should be chosen such that the road speed most closely approaches 50 km/h at this engine speed. However, if the vehicle has more than three forward gears, the first gear should not be used.

A2.4.2.2 VEHICLE WITH AN AUTOMATIC GEAR BOX. The vehicle should approach the line *AA* at a steady speed of 50 km/h or at three quarters of its maximum speed, whichever is the lower. Where alternative forward drive positions are available, the position which results in the highest sound level of the vehicle should be selected.

The selector position which is used only for engine braking, parking or similar slow manœuvres of the vehicle should be excluded.

A2.5 Statement of results

All readings taken on the sound level meter should be stated in the report.

The basis of horsepower rating, if appropriate, should be stated in the report.

The state of loading of the vehicle should also be specified in the report.

MOTORCYCLE INDUSTRY COUNCIL SUPPORTED NOISE TEST PROCEDURE FOR NEW VEHICLES

1. INTRODUCTION

This Standard establishes maximum sound levels for motorcycles and motor driven cycles and describes the test procedure, environment, and instrumentation for determining these sound levels.

2. INSTRUMENTATION

The following instrumentation shall be used for the measurement required:

2.1 A sound level meter which meets the requirements of International Electroacoustic Commission Publication 179, Precision Sound Level Meters.

2.1.1 Alternatively, a microphone/magnetic tape recorder/indicating meter system whose overall response is equivalent to the above may be used.

2.2 A sound level calibrator (see paragraph 4.5)

2.3 A calibrated windscreen or nose cone (see paragraph 4.4)

3. PROCEDURE

3.1 A test site suitable for the purpose of measurements shall consist of a flat open space free of large reflecting surfaces such as signboards, buildings, or hillsides located within 100 ft. of either the vehicle or the microphone.

3.1.1 The surface of the ground within the measurement area shall be dry concrete or asphalt, free from powdery snow, loose soil or ashes.

3.1.2 Because bystanders may have an appreciable influence on meter response when they are in the vicinity of the vehicle or the microphone, not more than one person other than the observer reading the meter shall be within 50 ft. of the vehicle or microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

3.1.3 The ambient sound level (including wind effects) due to sources other than the vehicle being measured shall be at least 10dbA lower than the level of the tested vehicle.

3.1.4 The path of vehicles shall be of relatively smooth, dry concrete or asphalt, free of extraneous matter such as gravel.

3.1.5 The microphone shall be located 50 ft. from the centerline of the vehicle path at a height of 4 ft. above the ground plane.

3.1.6 An acceleration point shall be established on the vehicle path 25 ft. before the line through the microphone and normal vehicle path.

3.2 VEHICLE OPERATIONS

3.2.1 The vehicle shall use second gear. Vehicles which reach maximum rated engine speeds before reaching a point 25 ft. beyond the microphone shall be tested in third gear.

3.2.2 The vehicle shall proceed along the test path at a constant approach speed which shall correspond to either the engine speed of 60% of the speed at which the engine develops maximum horsepower or at 30 mph whichever is lower. When the front of the vehicle reaches the acceleration point, the throttle shall be opened wide, and maintained until the front of the vehicle is 100 ft. beyond the microphone, or until the maximum rated engine speed is reached, at which point the throttle shall be closed.

3.2.3 Wheel slip which affects the maximum sound level must be avoided.

3.3 MEASUREMENTS

3.3.1 The meter shall be set for "fast" response and for the A-weighted network.

3.3.2 The meter shall be observed while the vehicle is accelerating. The applicable reading shall be the highest sound level obtained for the run, ignoring unrelated peaks due to extraneous ambient noises. Sufficient preliminary runs to familiarize the driver and to stabilize the engine operating conditions shall be made before measurements begin. Immediately after the preliminary runs, at least two measurements shall be made for each side of the vehicle. All of the values shall be recorded.

3.3.3 The sound level for each side of the vehicle shall be the average of the two highest readings which are within 2db of each other. The sound level reported shall be that of the louder side of the vehicle.

4. GENERAL COMMENTS

4.1 It is strongly recommended that technically trained personnel select equipment and that tests be conducted only by qualified persons trained in the current techniques of sound measurement.

4.2 An additional 2db allowance over the sound level limit is recommended to provide for variations in test site, vehicle operation temperature gradients, wind velocity gradients, test equipment, and inherent differences in nominally identical vehicles.

4.3 Instrument manufacturers' specification for orientation of the microphone relative to the meter should be adhered to.

4.4 When a windscreen is required, a previously calibrated windscreen should be used. It is recommended that measurements be made only when wind velocity is below 12 mph.

4.5 Instrument manufacturers' recommended calibration practice should be followed. Field calibration should be made immediately before and after each test sequence. Either an external calibrator or internal calibrator means is acceptable for field use, providing that external calibration is accomplished immediately before and after field use.

5. REFERENCE MATERIAL

Suggested reference material is as follows:

USASI SI. 1-1960 Acoustical Terminology
USASI SI. 2-1962 Physical Measurement of Sound.
International Electroacoustic Commission Publication 179, Precision Sound Level Meters (available from USASI).

(Application for copies of these documents should be addressed to ANSI, 10 East 40th Street, New York, New York 10016).

Proposed M.I.C. 4-Mode Motorcycle Noise Measurement Test Data Sheet

Manufacturer: ____________________

Model: ____________________

Displacement: ____________________

☐ **Motorcycle**

☐ **Motor-Driven Cycle**

California Law defines a motor-driven cycle on the basis of the engine producing less than 15 gross brake horsepower.

Motorcycle Data

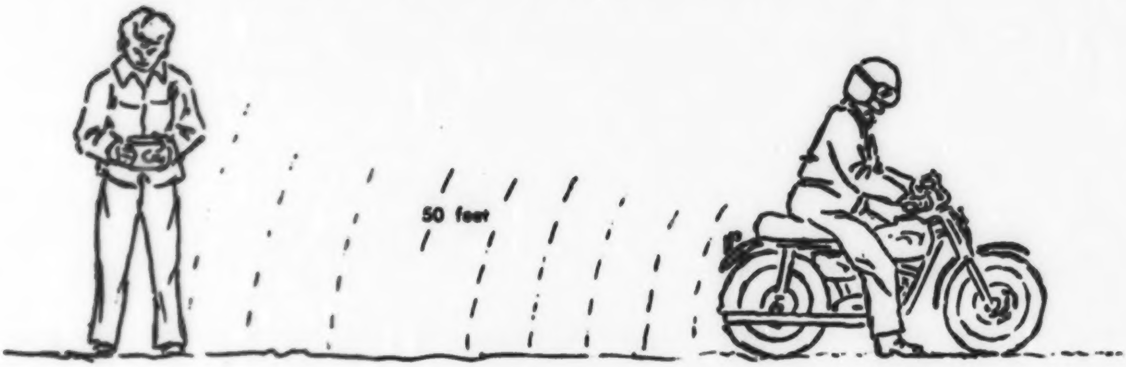
Mode Number	Description	dB(A) Test Result	Multiply By Weighting Factor	Weighted Result
1.	CHP Maximum Noise Procedure		0.5	
2.	Steady 65 mph driveby (top gear)		0.2	
3.	Steady 40 mph driveby (top gear)		0.2	
4.	2000 rpm (neutral) Vehicle stationary with front at end point (refer to CHP Procedure)		0.1	
			Total - (Add Weighted Results)	

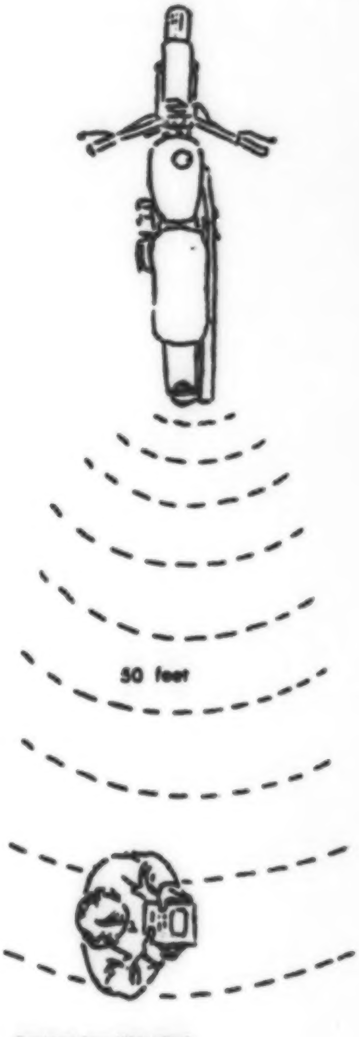
Motor-Driven Cycle Data

Mode Number	Description	dB(A) Test Result	Multiply By Weighting Factor	Weighted Result
1.	CHP Maximum Noise Procedure		0.5	
3.	Steady 40 mph driveby (top gear)		0.4	
4.	200 rpm (neutral) Vehicle stationary with front at end point (refer to CHP Procedure)		0.1	
			Total - (Add Weighted Results)	

NOTE: THIS METHOD DIFFERS FROM THE PRECEDING M.I.C. SUPPORTED PROCEDURE.

NOISE MEASUREMENT PROCEDURE USED FOR QUALIFICATION IN AMERICAN MOTORCYCLE ASSOCIATION SANCTIONED OFF-ROAD COMPETITION





Reprinted from AMA NEWS

RECOMMENDED NOISE TESTING METHOD

During the FIM spring, 1972, congress held in Geneva, Switzerland, the world governing body for the sport of motorcycling adopted noise standards and testing methods based on proposals made by the delegates of the American federation. After experiencing difficulties with various methods designed for technical accuracy and sophistication, the FIM turned to the American Motorcycle Association for suggestions with the hope that a world-wide noise abatement program could be established, based on a practical, easily-administered method of noise testing.

The FIM method provides that all machines under examination be measured at a distance of 50 feet (15.2m). They should be running in neutral with the noise level reading taken at a pre-determined motor speed, depending upon the size of the motorcycle.

A hand-held meter, such as that available from the AMA, should be held about 4 feet (1.2m) from the ground (a comfortable posture with the elbows bent) with the microphone pointing at a right angle to the motorcycle. The individual holding the meter, preferably the referee in charge or someone appointed by him, takes the reading of each motorcycle and reports it to a clerk who should record it beside the contestant's number on an entry list.

With the motorcycle started and running in neutral, the motor is accelerated to a certain rpm and held there just long enough for the reading to be taken. Care should be taken not to over-rev the motor or to hold it at speed too long.

Below are the reading speeds established by the FIM:

50cc to 75cc	6000rpm
100cc to 125cc	5500rpm
175cc to 250cc	5000rpm
350cc to 500cc	4500rpm
over 500cc	4000rpm

Note that these recommendations are based on traditional FIM class designations. If a motor size falls between categories, it should be moved to the next larger class. For example, a 150cc machine should be measured at 5000 rpm, falling into the class of motorcycles up to 250cc.

If the motorcycle has no tachometer, the testing crew may want to use a counter which attaches to the electrical system, a method suggested by the FIM. If no such device is available, the motor speed should be estimated at 2/3 maximum safe revolutions.

No motorcycle, tested at the motor speed designated for its motor class, may exceed 92 decibels (92dB(a))[*] and be legal for AMA amateur competition or professional moto-cross.

Common sense should be followed in administering this test. For example, only the motorcycle being tested should be running. An open area should be chosen so that the contestant will not be jeopardized by noise echoing from walls or other large objects.

This method is designed for its simplicity. More sophisticated and accurate methods are available, but they are more complicated, difficult and expensive to administer. Furthermore, with the more complicated methods, the individual being tested can usually find more ways to manipulate the noise level of his machine and control the results to his benefit.

For those interested in improving the sport of motorcycling by reducing offensive noise, this simple method, administered in a spirit of cooperation by official and contestant alike, is a most convenient and effective technique.

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[*] This level is now set at 90 dBA.

NOTE – NEW INFORMATION

The two remaining motorcycle noise test procedures are new Society of Automotive Engineers recommendations received after writing of the report text. Some of the shortcomings discussed in the Measurement Procedures section of Chapter 4, such as variable rider weight, have been addressed in the new standards. The new SAE Recommended Practice J331a – Sound Levels for Motorcycles – is a revised version of J331 similar to the California Highway Patrol measurement standard. Recommended Practice XJ47 – Maximum Sound Level Potential for Motorcycles – is essentially the old J331 referred to in the text.

September 10, 1973

SOUND LEVELS FOR
MOTORCYCLES – SAE XJ 331a

SAE RECOMMENDED
PRACTICE

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1. SCOPE

This SAE Recommended Practice establishes the test procedure, environment, and instrumentation for determining sound levels typical of normal motorcycle operation.

2. INSTRUMENTATION

2.1 The following instrumentation shall be used, where applicable:

2.1.1 A sound level meter which meets the Type 1 requirements of the American National Standard Specification for Sound Level Meters S1.4-1971. As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape recorder and/or a graphic level recorder or indicating meter providing the system meets the requirements of SAE Recommended Practice J184, Qualifying a Sound Data Acquisition System.

2.1.2 An Acoustic Calibrator (see Section 6.4.4).

2.1.3 A calibrated engine speed tachometer having the following characteristics:

(a) Steady state accuracy of better than 1 percent.

(b) Transient response: Response to a step input will be such that within 10 engine revolutions the indicated rpm will be within 2 percent of the actual rpm.

Note: This is a retyped copy of the pending SAE Standard.

2.1.4 A speedometer with steady state accuracy of at least ±10 percent.

2.1.5 An anemometer with steady state accuracy of at least ±10 percent.

2.1.6 An acceptable wind screen may be used with the microphone. To be acceptable the screen must not affect the microphone response more than ± 1 dB for frequencies of 20–4000 Hz or ± 1-1/2 dB for frequencies of 4000 - 10,000 Hz.

3. TEST SITE

3.1 The test site for measuring sound levels of motorcycles shall be a flat open space free of large sound reflecting surfaces (other than the ground), such as parked vehicles, signboards, buildings, or hillsides, located within 100 ft (30.4 m) radius of the microphone location and the following points on the vehicle path:

(a) The microphone point.

(b) A point 50 ft (15.2 m) before the microphone point.

(c) A point 50 ft (15.2 m) beyond the microphone point.

3.2 The measurement area within the test site shall meet the following requirements and be layed out as described:

3.2.1 The surface of the ground within at least the triangular area formed by the microphone location and the points 50 ft (15.2 m) prior to and 50 ft (15.2 m) beyond the microphone point shall be dry concrete or asphalt, free from snow, soil, or other extraneous material.

3.2.2 The vehicle path shall be of relatively smooth, dry concrete or asphalt, free of extraneous materials such as gravel, and of sufficient length for safe acceleration, deceleration, and stopping of the vehicle.

3.2.3 The microphone shall be located 50 ft (15.2 m) from the centerline of the vehicle path and 4 ft (1.2 m) above the ground plane.

3.2.4 The following points shall be established on the vehicle path:

(a) Microphone point – a point on the centerline of the vehicle path where a normal through the microphone location intersects the vehicle path.

(b) End point – a point on the vehicle path 100 ft (30.4 m) beyond the microphone point.

(c) Acceleration point – a point on the vehicle path 25 ft (7.6 m) prior to the microphone point.

3.2.5 The test area layout in Figure 1 shows a directional approach from left to right with one microphone location, for purposes of clarity. Sound level measurements are to be made on both sides of the vehicle; therefore, it will be necessary to establish either a corresponding clear area or end points and acceleration points for approaches from both directions.

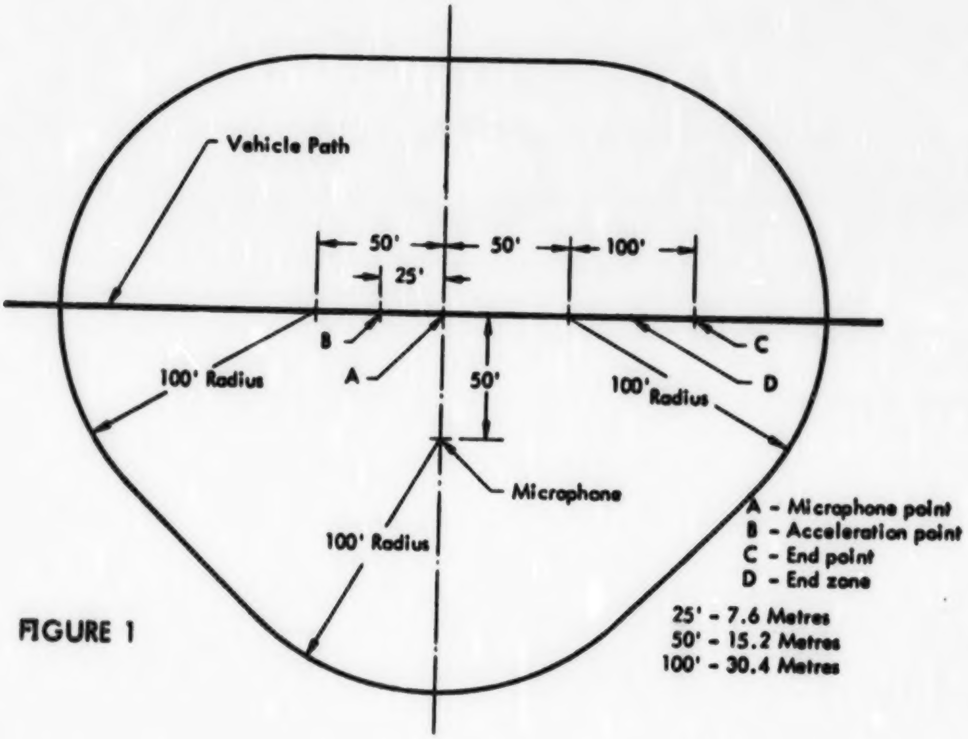
Vehicle Path
50'
50'
100'
25'
B
C
A
50'
D
100' Radius
100' Radius
Microphone
100' Radius
A - Microphone point
B - Acceleration point
C - End point
D - End zone
25' - 7.6 Metres
50' - 15.2 Metres
100' - 30.4 Metres

FIGURE 1

4. TEST WEIGHT

4.1 At the start of the test series, the vehicle shall be filled with fuel and lubricant to not less than 75 percent of capacity.

4.2 The combined weight of the test rider and test equipment used on the vehicle shall be not more than 175 lbs (79.4 kg) nor less than 165 (74.8 kg). Weights shall be placed on the vehicle saddle behind the driver to compensate for any difference between the actual driver/equipment load and the required 165 lb (74.8 kg) minimum.

5. PROCEDURE

5.1 The vehicle shall use second gear unless during the test under acceleration the engine speed at maximum rated net horsepower is reached before the vehicle reaches a point 25 ft (7.6 m) beyond the microphone point in which case the vehicle shall be tested in third gear.

5.2 For the test under acceleration the vehicle shall proceed along the vehicle path at a constant approach speed which shall correspond to either an engine speed of 60 percent of the engine speed at maximum rated net horsepower or a vehicle speed of 30 mph (48 km/h), whichever is slower. When the front of the vehicle reaches the acceleration point, rapidly and fully open the throttle and accelerate until the front of the vehicle is 100 ft (30.4 m) beyond the microphone point, or until the engine speed at maximum rated horsepower is reached, at which point the throttle shall be closed. Wheel slip which effects the maximum sound level shall be avoided.

5.3 When excessive or unusual noise is noted during deceleration, the following test shall be performed with sufficient runs to establish maximum sound level under deceleration.

5.3.1 For the test under deceleration, the vehicle shall proceed along the vehicle path at an engine speed at maximum rated net horsepower in the gear selected for the test under acceleration. At the end point, the throttle shall be rapidly and fully closed, and the vehicle allowed to decelerate to an engine speed of one-half of the rpm at maximum rated net horsepower.

5.4 Sufficient preliminary runs to familiarize the driver and to establish the engine operating conditions shall be made before measurements begin. The engine temperature shall be within the normal operating range prior to each run.

6. MEASUREMENTS

6.1 The sound level meter shall be set for "fast" response and for the A-weighting network.

6.2 The meter shall be observed while the vehicle is accelerating or decelerating. Record the highest sound level obtained for the run, ignoring unrelated peaks due to extraneous ambient noises. All values shall be recorded.

6.3 At least six measurements shall be made for each side of the vehicle. The highest and the lowest reading shall be discarded; the sound level for each side shall be the average of the remaining four, which shall be within 2 dB of each other. The sound level reported shall be for that side of the vehicle having the highest sound level.

6.4 The ambient sound level (including wind effects) at the test site due to sources other than the vehicle being measured shall be at least 10 dB lower than the sound level produced by the vehicle under test.

6.5 Wind speed at the test site during tests shall be less than 12 mph (19 km/h).

7. GENERAL COMMENTS

7.1 Technically competent personnel should select equipment and the tests should be conducted only by trained and experienced persons familiar with the current techniques of sound measurement.

7.2 While making sound level measurements, not more than one person other than the rider and the observer reading the meter shall be within 50 ft (15.2 m) of the vehicle or microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

7.3 The test rider should be fully conversant with and qualified to ride the machine under test and be familiar with the test procedure.

7.4 Proper use of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer should be referred to for both recommended operation of the instrument and precautions to be observed. Specific items to be considered are:

7.4.1 The type of microphone, its directional response characteristics, and its orientation relative to the ground plane and source of noise.

7.4.2 The effects of ambient weather conditions on the performance of all instruments (e.g., temperature, humidity, and barometric pressure).

7.4.3 Proper signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems.

7.4.4 Proper acoustical calibration procedure, to include the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Internal calibration means is acceptable for field use, provided that external calibration is accomplished immediately before or after field use.

8. REFERENCES

Suggested reference material is as follows:

8.1 ANSI S1.1 - 1960, Acoustical Terminology

8.2 ANSI S1.2 - 1962, Physical Measurement of Sound

8.3 ANSI S1.4 - 1971, Specification for Sound Level Meters

8.4 ANSI S1.13 - 1971, Method of Measurement of Sound Pressure Levels

8.5 SAE J184, Qualifying a Sound Data Acquisition System

8.6 SAE J47, Maximum Sound Level Potential for Motorcycles. This procedure is recommended for determining the vehicle's maximum potential sound level. The procedure does not represent normal motorcycle safe operating practice.

APPENDIX

The SAE recommends that the following sound levels, when measured in accordance with the test procedure described above, be used as a reference in the design and development of motorcycles. A 2 dB (A) allowance is recommended to provide for variations in test site, temperature and wind gradients, test equipment and inherent differences in nominally identical vehicles.

Engine Displacement	A-Weighted Sound Level
169 cc and less	82 dB(A)
170 cc thru 500 cc	84 dB(A)
more than 500 cc	86 dB(A)

September 10, 1973

MAXIMUM SOUND LEVEL, POTENTIAL FOR MOTORCYCLES - SAE XJ 47

SAE RECOMMENDED PRACTICE

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1. SCOPE

This SAE Recommended Practice establishes the test procedure, environment and instrumentation for determining maximum sound level potential for motorcycles.

2. INSTRUMENTATION

2.1 The following instrumentation shall be used, where applicable:

2.1.1 A sound level meter which meets the Type 1 requirements of the American National Standard Specification for Sound Level Meters (S1.4-1971). As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape recorder and/or a graphic level recorder or indicating meter providing the system meets the requirements of SAE Recommended Practice J184, Qualifying a Sound Data Acquisition System.

2.1.2 An acoustic calibrator (see Section 6.4.4).

2.1.3 A calibrated engine speed tachometer having the following characteristics.

(a) Steady state accuracy of better than 1 percent.

(b) Transient response: Response to a step input will be such that within 10 engine revolutions the indicated rpm will be within 2 percent of the actual rpm.

Note: This is a retyped copy of the pending SAE Standard.

2.1.4 An anemometer with steady state accuracy within ± 10 percent.

2.1.5 An acceptable wind screen may be used with the microphone. To be acceptable, the screen must not affect the microphone response more than ±1 dB for frequencies of 20 to 4000 Hz or ± 1-1/2 dB for frequencies of 4000 to 10,000 Hz.

3. TEST SITE

3.1 The test site for measuring sound levels of motorcycles shall be a flat open space free of large sound reflecting surfaces (other than the ground) such as parked vehicles, signboards, buildings, or hillsides, located within 100 ft (30.4 m) radius of the microphone location and the following points on the vehicle path:

(a) The microphone point.

(b) A point 50 ft (15.2 m) before the microphone point.

(c) A point 50 ft (15.2 m) beyond the microphone point.

3.2 The measurement area within the test site shall meet the following requirements and be layed out as described:

3.2.1 The surface of the ground within at least the triangular area formed by the microphone location and the points 50 ft (15.2 m) prior to and 50 ft (15.2 m) beyond the microphone point shall be dry concrete or asphalt, free from snow, soil, or other extraneous material.

3.2.2 The vehicle path shall be of relatively smooth, dry concrete or asphalt, free of extraneous materials such as gravel, and of sufficient length for safe acceleration deceleration, and stopping of the vehicle.

3.2.3 The microphone shall be located 50 ft (15.2 m) from the centerline of the vehicle path and 4 ft (1.2 m) above the ground plane.

3.2.4 The following points shall be established on the vehicle path:

(a) Microphone point - a point on the centerline of the vehicle path where a normal through the microphone location intersects the vehicle path.

(b) End point - a point on the vehicle path 25 ft (7.6 m) beyond the microphone point.

(c) Acceleration point - a point on the vehicle path at least 25 ft (7.6 m) prior to the microphone point established by the method described in paragraph 4.1.

3.2.5 The test area layout in Figure 1 shows a directional approach from left to right with one microphone location for purposes of clarity. Sound level measurements are to be made on both sides of the vehicle; therefore, it will be necessary to establish either a second microphone location on the opposite side of the vehicle path with a corresponding clear area or end points, and acceleration points for approaches from both directions.

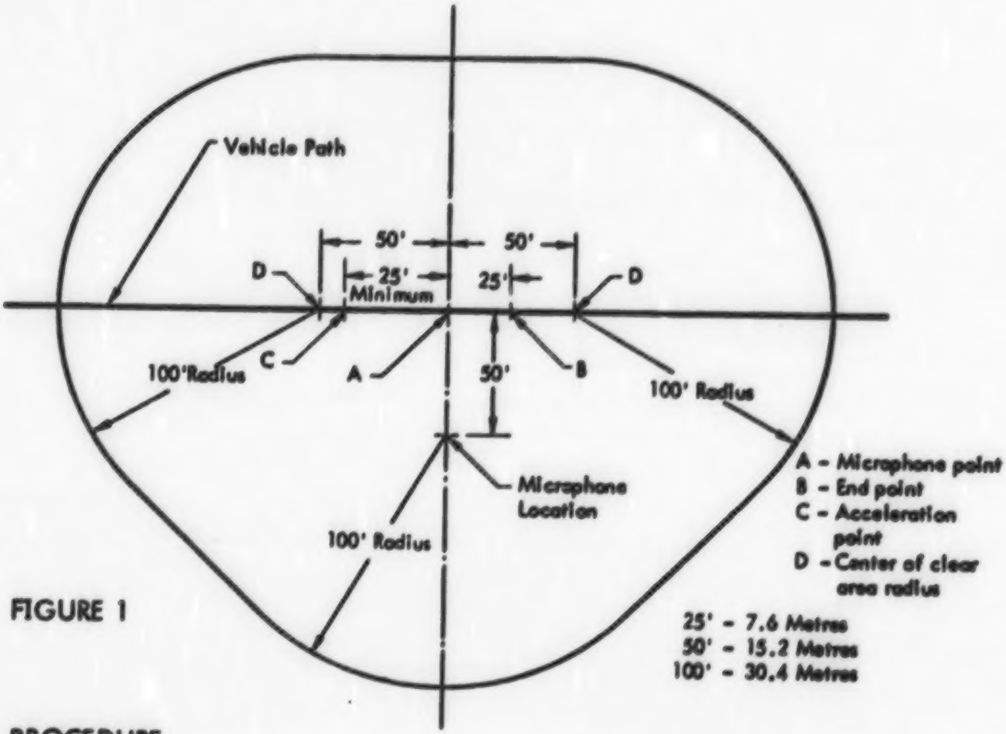
Vehicle Path
50'
50'
D
25'
Minimum
25'
D
100'Radius
C
A
50'
B
100' Radius
Microphone Location
100' Radius
A - Microphone point
B - End point
C - Acceleration point
D - Center of clear area radius
25' - 7.6 Metres
50' - 15.2 Metres
100' - 30.4 Metres

FIGURE 1

4. PROCEDURE

4.1 To establish the acceleration point, the end point shall be approached in low gear from the reverse direction at a constant road speed obtained from 60 percent of the engine speed at maximum rated net horsepower. When the front of the vehicle reaches the end point, the throttle shall be rapidly and fully opened to accelerate past the microphone point under wide open throttle. By trial, the lowest transmission gear shall be selected that will result in the vehicle traveling the shortest distance from the end point to the place where the engine speed at maximum rated net horsepower is reached, but which is not less than 25 ft (7.6 m) past the microphone point. The location of the front of the vehicle on the vehicle path when the engine speed at maximum rated net horsepower is attained shall be the acceleration point for test runs to be made in the opposite direction.

4.1.1 When the procedure described in paragraph 4.1 results in a dangerous or unusual operating condition such as wheel spin, front wheel lifting or other unsafe conditions, the next higher gear shall be selected for the test and the procedure rerun to establish the acceleration point. In any event the procedure shall result in the vehicle being at the end point when the engine speed at maximum rated net horsepower is attained.

4.2 For the test under acceleration, the vehicle shall proceed along the vehicle path at a constant approach speed in the gear selected in paragraph 4.1 and at 60 percent of the engine speed at maximum rated net horsepower. When the front of the vehicle reaches the acceleration point, the throttle shall be rapidly and fully opened. Full acceleration shall continue until the engine speed at maximum rated net horsepower is reached, which shall be at the end point, at which time the throttle shall be closed. Wheel slip which affects the maximum sound level shall be avoided, and the manufacturer's safe maximum engine speed shall not be exceeded.

4.3 When excessive or unusual noise is noted during deceleration, the following test shall be performed with sufficient runs to establish maximum sound level under deceleration.

4.3.1 For the test under deceleration, the vehicle shall approach the end point from the reverse direction at the engine speed at maximum rated horsepower in the gear selected for the test under acceleration. At the end point, the throttle shall be rapidly and fully closed and the vehicle shall be allowed to decelerate to an engine speed of one-half of the rpm at maximum rated net horsepower.

4.4 Sufficient preliminary runs to familiarize the driver and to establish the engine operating conditions shall be made before measurements begin. The engine temperature shall be within the normal operating range prior to each run.

5. MEASUREMENTS

5.1 The sound level meter shall be set for "fast" response and for the A-weighting network.

5.2 The meter shall be observed while the vehicle is accelerating or decelerating. The highest sound level obtained for each run shall be recorded ignoring unrelated peaks due to extraneous ambient noises.

5.3 At least six measurements shall be made for each side of the vehicle. The highest and the lowest reading shall be discarded; the sound level for each side shall be the average of the remaining four, which shall be within 2 dB of each other. The sound level reported shall be for that side of the vehicle having the highest sound level.

5.4 The ambient sound level (including wind effects) at the test site due to sources other than the vehicle being measured shall be at least 10 dB lower than the sound level produced by the vehicle under test.

5.5 Wind speed at the test site during tests shall be less than 12 mph (19 km/h).

6. GENERAL COMMENTS

6.1 Technically competent personnel should select equipment, and the tests should be conducted only by trained and experienced persons familiar with the current techniques of sound measurement.

6.2 While making sound level measurements, not more than one person other than the rider and the observer reading the meter shall be within 50 ft (15.2 m) of the vehicle or microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

6.3 The test rider should be fully conversant with and qualified to ride the machine under test and be familiar with the test procedure.

6.4 Proper use of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer should be referred to for both recommended operation of the instrument and precautions to be observed. Specific items to be considered are:

6.4.1 The type of microphone, its directional response characteristics, and its orientation relative to the ground plane and source of noise.

6.4.2 The effects of ambient weather conditions on the performance of all instruments (e.g., temperature, humidity, and barometric pressure).

6.4.3 Proper signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems.

6.4.4 Proper acoustical calibration procedure, to include the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Internal calibration is acceptable for field use, provided that external calibration is accomplished immediately before or after field use.

6.5 Vehicles used for tests must not be operated in a manner such that the break-in procedure specified by the manufacturer is violated.

7. REFERENCES

Suggested reference material is as follows:

7.1 ANSI S1.1 - 1960, Acoustical Terminology

7.2 ANSI S1.2 - 1962, Physical Measurement of Sound

7.3 ANSI S1.4 - 1971, Specification for Sound Level Meters

7.4 ANSI S1.13 - 1971, Method of Measurement of Sound Pressure Levels

7.5 SAE J184, Qualifying a Sound Data Acquisition System

7.6 SAE J331, Sound Levels for Motorcycles. This procedure is recommended for use in obtaining motorcycle sound levels typical of normal road operation.

APPENDIX

The SAE recommends that the following sound levels, when measured in accordance with the test procedure described above, be used as a reference in the design and development of motorcycles. A 2 dB(A) allowance is recommended to provide for variations in test site, temperature and wind gradients, test equipment, and inherent differences in nominally identical vehicles.

Engine Displacement	A-Weighted Sound Level
169 cc and less	86 dB(A)
170 cc thru 500 cc	88 dB(A)
more than 500 cc	90 dB(A)

SAE XJ47

2.1.5 Paragraph 2.1.5 has been rewritten to agree with SAE J34 with the requirements for the windscreen.

3. Paragraphs 3.1 and 3.1.1 have been combined. Paragraph 3.1.2 and 3.1.3 have been removed from the Site requirements and placed under paragraph 5, Measurements, and are now paragraphs 5.4 and 5.5 with no wording change.

APPENDIX

The recommended A-weighted sound levels have been retyped as they were under the proposals prior to the June draft. The numbers typed in the June 8 draft were incorrect.

APPENDIX C

CURRENT REGULATIONS

State and municipal vehicle noise regulations display a variety of nature and intent. Limits are usually presented regarding in-use vehicle operation, and some authorities such as California and Chicago require noise certifications of new models before sale is permitted. Noise measurement techniques are predominantly non-standardized between jurisdictions, with sundry procedures and distances being prescribed. Most regulations do not specifically identify motor-driven cycles, but include them in an "other vehicles" category not applying to motorcycles and heavy trucks. The regulations included here, representing the country's most sophisticated and restrictive, have been edited to motorcycle application, and sections which deal generally with horns or equipment installation pertaining to motorcycles have been omitted.

FROM CALIFORNIA STATE VEHICLE CODE

Section 23130. (a) No person shall operate either a motor vehicle or combination of vehicles of a type subject to registration at any time or under any condition of grade, load, acceleration or deceleration in such a manner as to exceed the following noise limit for the category of motor vehicle within the speed limits specified in this section:

		Speed Limit of 35 mph or less	Speed Limit of more than 35 mph
(1)	Any motor vehicle with a manufacturer's gross vehicle weight rating of 6,000 pounds or more....		
(2)	Any motorcycle other than a motor-driven cycle	82 dB(A)	86 dB(A)
(3)	Any other motor vehicle and any combination of vehicles towed by such motor vehicle	76 dB(A)	82 dB(A)

(b) The noise limits established by this section shall be based on a distance of 50 feet from the center of the lane of travel within the speed limit specified in this section. The Department of the California Highway Patrol may provide for measuring a distance closer than 50 feet from the center of the lane of travel. In such a case, the measuring devices shall be so calibrated as to provide for measurements equivalent to the noise limit established by this section measured at 50 feet.

(d) This section applies to the total noise from a vehicle or combination of vehicles and shall not be construed as limiting or precluding the enforcement of any other provisions of this code relating to motor vehicle exhaust noise.

Section 23130.5. (a) Notwithstanding the provisions of subdivision (a) of Section 23130, the noise limits, within a speed zone of 35 miles per hour or less on level streets, or streets with a grade not exceeding plus or minus 1 percent, for the following categories of motor vehicles, or combinations of vehicles, which are subject to registration, shall be:

(1) Any motor vehicle with a manufacturer's gross vehicle weight rating of 6,000 pounds or more....

(2) Any motorcycle other than a motor-driven cycle-- 77 dB(A)

(3) Any other motor vehicle and any combination of vehicles towed by such motor vehicle------ 74 dB(A)

No person shall operate such a motor vehicle or combination of vehicles in such a manner as to exceed the noise limits specified in this section.

The provisions of subdivisions (c), (d), (e), and (f) of Section 23130 shall apply to this section.

(d) The noise limits established by this section shall be based on a distance of 50 feet from the center of the lane of travel within the speed limit specified in this section. The Department of the California Highway Patrol may provide for measuring at distances closer than 50 feet from the center of the lane of travel. In such a case, the measuring devices shall be so calibrated as to provide for measurements equivalent to the noise limit established by this section measured at 50 feet.

Section 27150. (a) Every motor vehicle subject to registration shall at all times be equipped with an adequate muffler in constant operation and properly maintained to prevent any excessive or unusual noise, and no muffler or exhaust system shall be equipped with a cutout, bypass, or similar device.

(b) Subdivision (a) shall also apply to motorcycles operated off the highways, except motorcycles being operated in an organized racing or competitive event conducted on a closed course. For the purposes of this subdivision, "closed course" means a permanent motor racing facility which has one or more of the following:

(1) Safety crash walls.
(2) Grandstands which seat 500 persons or more.
(3) Sanitation facilities for persons attending events.
(4) A business license or permit from a local authority to conduct motor racing or competition events.

Section 27151. No person shall modify the exhaust system of a motor vehicle in a manner which will amplify or increase the noise emitted by the motor of such vehicle, above that emitted by the muffler originally installed on the vehicle and the original muffler shall comply with all of the requirements of this chapter. No person shall operate a motor vehicle with an exhaust system so modified.

Section 27160. (a) No person shall sell or offer for sale a new motor vehicle which produces a maximum noise exceeding the following noise limit at a distance of 50 feet from the centerline of travel under test procedures established by the department:

(1)	Any motorcycle manufactured before 1970	92 dbA
(2)	Any motorcycle, other than a motor-driven cycle, manufactured after 1969, and before 1973	88 dbA
(3)	Any motorcycle, other than a motor-driven cycle, manufactured after 1972, and before 1975	86 dbA
(4)	Any motorcycle, other than a motor-driven cycle, manufactured after 1974, and before 1978	80 dbA
(5)	Any motorcycle, other than a motor-driven cycle, manufactured after 1977, and before 1988	75 dbA
(6)	Any motorcycle, other than a motor-driven cycle, manufactured after 1987	70 dbA
(13)	Any other motor vehicle manufactured after 1967, and before 1973	86 dbA
(14)	Any other motor vehicle manufactured after 1972, and before 1975	84 dbA
(15)	Any other motor vehicle manufactured after 1974, and before 1978	80 dbA
(16)	Any other motor vehicle manufactured after 1977, and before 1988	75 dbA
(17)	Any other motor vehicle manufactured after 1987	70 dbA

(b) Test procedures for compliance with this section shall be established by the department, taking into consideration the test procedures of the Society of Automotive Engineers.

CHAPTER 5. EQUIPMENT OF OFF-HIGHWAY VEHICLES

Section 38275. (a) Every off-highway motor vehicle subject to identification shall at all times be equipped with an adequate muffler in constant operation and properly maintained so as to meet the requirements of Section 38280, and no muffler or exhaust system shall be equipped with a cutout, bypass, or similar device.

(b) The provisions of subdivision (a) shall not be applicable to vehicles being operated off the highways in an organized racing or competitive event upon a closed course and which is conducted under the auspices of a recognized sanctioning body or by permit issued by the local governmental authority having jurisdiction.

Section 38280. (a) Notwithstanding the provisions of Section 27160, no person shall sell or offer for sale a new off-highway motor vehicle subject to identification which produces a maximum noise exceeding the following noise limit at a distance of 50 feet from the centerline of travel under test procedures established by the Department of the California Highway Patrol:

(1) Any such vehicle manufactured on or after January 1, 1972, and before January 1, 1973 --- 92 dbA
(2) Any such vehicle manufactured on or after January 1, 1973, and before January 1, 1975 --- 88 dbA
(3) Any such vehicle manufactured on or after January 1, 1975 -------------------------------- 86 dbA

(d) Test procedures for compliance with this section shall be established by the Department of the California Highway Patrol, taking into consideration the test procedures of the Society of Automotive Engineers.

CHICAGO NOISE ORDINANCE

Reproduced from best available copy.

From Chapter 17, Chicago Municipal Code

17-4.7 (a) It shall be unlawful for any person to operate any motor of a motor vehicle of a weight in excess of four tons (8.000 lbs.)....

(b) No person shall sell, or offer for sale, a new motor vehicle that produces a maximum noise exceeding the following noise limit at a distance of 50 feet from the center line of travel under test procedures established by Section 17-4.24 of this chapter:

	Type of Vehicle	*Date of Manufacture*	*Noise Limit*
(1)	Motorcycle	before 1 Jan. 1970	92 dB(A)
	Same	after 1 Jan. 1970	88 dB(A)
	Same	after 1 Jan. 1973	86 dB(A)
	Same	after 1 Jan. 1975	84 dB(A)
	Same	after 1 Jan. 1980	75 dB(A)
(2)	Any motor vehicle with a gross vehicle weight of 8,000 pounds or more	after 1 Jan. 1968	88 dB(A)
(3)	Passenger cars, motor-driven cycle and any other motor vehicle	before 1 Jan. 1973	86 dB(A)
	Same	after 1 Jan. 1973	84 dB(A)
	Same	after 1 Jan. 1975	80 dB(A)
	Same	after 1 Jan. 1980	75 dB(A)

The manufacturer, distributor, importer, or designated agent shall certify in writing to the Commissioner that his vehicles sold within the City comply with the provisions of this section.

(c) No person shall operate within the speed limits specified in this section either a motor vehicle or combination of vehicles of a type subject to registration at any time or under any condition of grade, load, acceleration or deceleration in such manner as to exceed the following noise limit for the category of motor vehicle, based on a distance of not less than 50 feet from the center line of travel under test procedures established by Section 17-4.25 of this chapter:

		Noise Limit in Relation To Posted Speed Limit	
	Type of Vehicle	*35 MPH or Less*	*Over 35 MPH*
(1)	Any motor vehicle with a manufacturer's GVW rating of 8,000 lbs. or more, ...		
(2)	Any motorcycle other than a motor-driven cycle		
	before 1 Jan. 1978	82 dB(A)	86 dB(A)
	after 1 Jan. 1978	78 dB(A)	82 dB(A)
(3)	Any other motor vehicle and any combination of motor vehicles towed by such motor vehicle		
	after 1 Jan. 1970	76 dB(A)	82 dB(A)
	after 1 Jan. 1978	70 dB(A)	79 dB(A)

This section applies to the total noise from a vehicle or combination of vehicles and shall not be construed as limiting or precluding the enforcement of any other provisions of this code relating to motor vehicle mufflers for noise control.

(d) No person shall modify or change the exhaust muffler, intake muffler or any other noise abatement device of a motor vehicle in a manner such that the noise emitted by the motor vehicle is increased above that emitted by the vehicle as originally manufactured. Procedures used to establish compliance with this paragraph shall be those used to establish compliance of a new motor vehicle with the requirements of this article.

17-4.22(a) No person shall sell or offer for sale a new motor-driven recreational or off-highway vehicle, including dunebuggies, snowmobiles, all-terrain vehicles, go-carts, and mini-bikes, that produces a maximum noise exceeding the following noise limit at a distance of 50 feet from the center line of travel under test procedures established by Section 17-4.28 of this chapter:

Type of Vehicle	*Date of Manufacture*	*Noise Limit*
Snowmobile		
Any other vehicle including Dune buggy, all-terrain vehicle, go-cart, mini-bike	after 1 January 1971	86 dB(A)
	after 1 January 1973	82 dB(A)
	after 1 January 1975	73 dB(A)

(b) It shall be unlawful for any person to operate a motor-driven vehicle of a type not subject to registration for road use, at any time or under any condition of load, acceleration, or deceleration, in such a manner as to exceed the following noise limit at any point on property zoned for business or residential use at a distance of not less than 50 feet from the path of travel:

	Noise Limit
before 1 January 1973	86 dB(A)
after 1 January 1973	82 dB(A)

17-4.23 The operational performance standards established by this ordinance shall not apply to any public performance being conducted in accordance with the provisions of a special permit granted by the city for the conduct of a public performance.

17-4.24 Test procedures to determine whether maximum noise emitted by new motor vehicles sold or offered for sale meet the noise limits stated in Section 17-4.7(b) of this chapter shall be in substantial conformity with Standards and Recommended Practice established by the Society of Automotive Engineers, Inc., including SAE Standard J331; SAE Recommended Practice J184; SAE Recommended Practice J366; SAE Standard J986 and such other and further standards as may be propounded in the Code of Recommended Practices of the Department of Environmental Control.

17-4.25 Test procedures to determine whether maximum noise emitted by motor vehicles in use meet the noise limits stated in Section 17-4.7(c) of this chapter shall be in substantial conformity with Standards and Recommended Practice established by the Society of Automotive Engineers, Inc., including, SAE Standard J986; SAE Standard J331; Recommended Practice J366; Recommended Practice J184; and such other and further standards as may be propounded in the Code of Recommended Practices of the Department of Environmental Control.

From Article 5

COLORADO SPRINGS CITY ORDINANCE

Section
8-39. Classification, Measurement of Noise - For purposes of determining and classifying any noise as excessive or unusually loud as declared to be unlawful and prohibited by this Article, the following test measurements and requirements may be applied; provided, however, a violation of Section 8-38 may occur without the following measurements being made:

A. Noise occurring within the jurisdiction of the City shall be measured at a distance of at least twenty-five (25) feet from a noise source located within the public right-of-way, and if the noise source is located on private property or property other than the public right-of-way, at least twenty-five (25) feet from the property line of the property on which the noise source is located.

B. 1. The noise shall be measured on the "A" weighing scale on sound level meter of standard design and quality, and having characteristics established by the American National Standards Institute.

   2. For purposes of this Article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour, or twenty-five (25) miles per hour with a wind screen.

   3. In all sound level measurements consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurement.

Section

8-46. Vehicles Weighing Less than 10,000 Lbs. - A noise measured or registered as provided above from any vehicles weighing less than 10,000 lbs. in excess of 80 decibels in the "A" weighing scale in intensity shall be and is hereby declared to be excessive and unusually loud and unlawful.

FROM LAKEWOOD, COLORADO MUNICIPAL CODE

Section 10.57.080 MUFFLERS--PREVENTION OF NOISE. (1) It shall be unlawful for any person to operate, or for the owner to cause or knowingly permit the operation of any vehicle or combination of vehicles, within this municipality, which is not equipped with an adequate muffler in constant operation and properly maintained to prevent any unnecessary noise, and no such muffler or exhaust system shall be modified or used with a cutoff, bypass or similar device. No person shall modify the exhaust system of a motor vehicle in a manner which will amplify or increase the noise emitted by the motor of such vehicle above that emitted by a muffler of the type originally installed on the vehicle.

(2) For the purposes of this section, the definitions contained in Section 9.52.030 of the Lakewood Municipal Code shall be applicable.

Section 10.60.160 MOTOR VEHICLE NOISE. (1) It shall be unlawful for any person to drive or move or for the owner to cause or knowingly permit to be driven or moved, within this municipality, any motor vehicle which emits a noise sound pressure level in excess of the dB(A) established by subparagraphs (2) and (3) of this section. Noise from a motor vehicle within the public right-of-way shall be measured at a distance at least twenty-five feet from the near side of the nearest traffic lane being monitored and at a height of at least four feet above the immediate surrounding surface on a sound level meter of standard design and operated on the "A" weighting scale. Noise from a motor vehicle which is located other than within the public right-of-way shall be measured at a distance at least twenty-five feet from said motor vehicle and at a height of at least four feet above the immediate surrounding surface on a sound level meter of type 2 or better, as specified in the American National Standards Institute Publication S1.4-1971, or successor publications, and operated on the "A" weighting network.

(2) Motor vehicles weighing less than 10,000 pounds, manufacturer's gross vehicle weight (GVW). Any motor vehicle with a weight of less than 10,000 pounds, manufacturer's gross vehicle weight (GVW), or any combination of motor vehicles towed by such motor vehicle shall not emit a noise sound pressure level in excess of 80 decibels in the "A" weighting network dB(A).

(3) Motor vehicles weighing 10,000 pounds or more, ...

(4) Subparagraphs (2) and (3) of this section shall apply only to vehicles traveling on streets with a posted speed limit of forty-five (45) miles per hour or less.

APPENDIX D

MOTORCYCLE NOISE REDUCTION COSTS - SPECIFIC EXAMPLES

Motorcycle Category	CHP-Type Noise Level Change	Modifications	Production Cost Increase
> 200cc Highway (A)	From 86 to 84 dBA	• Smaller intake silencer apertures • 4 mufflers instead of 2	$15.00 + 15 lb
> 200cc Highway (B)	From 84 to 80 dBA	• Increase intake baffling and absorption • Increase exhaust baffling • Interior mechanical changes	~$40.00
> 200cc Highway (A)	From 84 to 78 dBA	• Installation of large truck intake silencer on passenger seat • Wrap engine and exhaust in heavy asbestos • Supplemental exhaust mufflers	Severe Engine Cooling Problems
> 200cc Highway (B)	From 85 to 80 dBA	• Increase intake silencer size • Frame change • Water cooling • Large double wall mufflers • Damped double engine case covers	$87.00 "Very Difficult"

Motorcycle Category	CHP-Type Noise Level Change	Modifications	Production Cost Increase
> 200cc Highway (B)	From 85 to 80 dBA	• Increase intake silencer size • Larger double walled mufflers • Frame change • Improved gear tooth finish • Damped double engine case covers	$51.00 "Very Difficult"
> 200cc Highway (B)	From 85.5 to 80 dBA	• Increase intake silencer size • Larger double walled mufflers • Damped double engine case covers • Improved gear tooth finish	$31.00 "Difficult"
> 200cc Dual Purpose (B)	From 84 to 80 dBA	• Increase intake silencer size • Larger double walled muffler • Frame change • Damped double engine case covers • Improved gear tooth finish	$38.00 "Very Difficult"
> 200cc Highway (A)	From 85 to 80 dBA	• Increase intake silencer size • Increase exhaust system size • Interior mechanical treatments	Reliability Unproven Performance Reduced 5% - 15%

NOTES: See following page.

NOTES:

A. Prototype existing machines.

B. Projected ability and costs for a specific model. Duplicated values for several models are not repeated. These modifications may not be possible by 1975.

C. This table does not present complete performance or quality degradation descriptions.

D. It is unlikely that a practical prototype has been constructed yet which emits a noise level during the CHP test of 75 dBA or less. Manufacturers claim that lead time of up to 5 years after complete 80 dBA levels are achieved will be required to produce 75 dBA machines.

APPENDIX E

NOISE REDUCTION OF MOTORCYCLES CURRENTLY IN USE

The prospect of quieting vehicles already produced and in use is an essential consideration in the reduction of transportation vehicle noise impact. In the case of motorcycles, requirement of such activity appears highly impractical. Development of retrofit packages consisting of intake and exhaust system replacements or modifications for many of the over 4 million motorcycles registered in the United States would be quite difficult for the multitude of existing models. In California, for example, it is reported that one motorcycle in 12 exceeds state noise regulations.* Beyond this, mechanical noises in these old machines may have increased beyond intake and exhaust levels obtained through retrofit parts, constituting a limit for potential improvement (excluding possibility of the still unproven shielding concept). Cost of parts and installation labor would average near $40 – a significant percentage of a used machine's value. More important, the requirement for retrofitting in no way assures such modifications will be properly effected and maintained by the vehicle owners. Many motorcycles become to their owners unique expressions of individuality, and thus the machines tend to become modified to personal taste. Unfortunately, a common constituent of such taste is loud noise. Hence, over 80 percent of all excessive noise violations issued by the California Highway Patrol to motorcyclists are due to exhaust system modifications made by the owner which cause the machine to exceed legal noise requirements. It becomes apparent that regulations specifying additional retrofit parts would find less compliance than existing noise regulations. Considering these facts, and the short turnover period of the motorcycle population (6 to 10 years – see Chapter 4), the most practical and effective approach to reduction of noise impact from motorcycles is vigilant enforcement of existing laws while new vehicle improvements take effect through attrition and replacement. The requirement of solid unit or all welded exhaust systems, especially for four-cycle machines which typically have low internal exhaust cleaning requirements, would assist in limiting future modifications.

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*Letter from California State Attorney General's office to "Motorcycle Owners, Riders and Enthusiasts"(M.O.R.E.), October 19, 1973.